RAILWAY ENGINEERING

AND MAINTENANCE OF WAY.

BRIDGES—BUILDINGS—CONTRACTING—SIGNALING—TRACK

Vol. VI | Chicago | FEBRUARY, 1910 | New York | No. 2

CLASSIFIED INDEX OF ADVERTISERS

Asbestos Products. All kinds.
Franklin Mfg. Co., Franklin, Pa.
Asbestos Roofing Slates.
Franklin Mfg. Co., Franklin, Pa.
Asbestos Sheathing.
Franklin Mfg. Co., Franklin, Pa.
Axle Washers.
Hubbard & Co., Pittsburg, Pa.
Ballast Cars.
Rodger Ballast Car Co., Chicago.
Ballast Placing Device.
Rodger Ballast Car Co., Chicago.
Ballast Unloaders.
Rodger Ballast Car Co., Chicago.
Bridge Paint.
Detroit Graphite Mfg. Co., Detroit, Mich.
Dixon, Joseph, Crucible Co., Jersey City.
Buckets, Automatic Grab.
G. H. Williams Co., Cleveland, O.
Buckets, Excavating.
G. H. Williams Co., Cleveland, O.
Bumping Posts.
Mechanical Mfg. Co., Chicago.
Scott & Sons, J. M., Racine, Wis.
Building Felts and Papers.
Franklin Mfg. Co., Franklin, Pa.
Cable Railways.
Wm. J. Haskins, New York City.
Car Replacers.
Johnson Wrecking Frog Co., Cleveland, O.
Cars.
Hicks Locomotive & Car Wks., Chicago.
Cars Ballast.
Hicks Locomotive & Car Wks., Chicago.
Rodgers Ballast Car Co., Chicago.
Cars Dump.
Hicks Locomotive & Car Wks., Chicago.
Rodgers Ballast Car Co., Chicago.
Cars Rebuilt.
Hicks Car & Locomotive Works, Chicago.
Cattleguards.
Standard Cattle Guard Co., Birmingham, Ala.
Chisels.
Hubbard & Co., Pittsburg, Pa.
Clam Shell Buckets.
Wm. J. Haskins, New York City.
Coal Miners' Tools.
Hubbard & Co., Pittsburg, Pa.
Coal and Ore Handling Machinery.
Rodgers Ballast Car Co., Chicago.
Wm. J. Haskins, New York City.
Coal Pockets and Equipment.
Wm. J. Haskins, New York City.
Concrete Mixers.
Marsh Co., Chicago.
Conveyors.
Wm. J. Haskins, New York City.
Contractors' Equipment and Supplies.
Hicks Locomotive & Car Wks., Chicago.
Crossing (See Frogs and Crossings).
Dump Cars.
Rodgers Ballast Car Co., Chicago.
Elevators.
Wm. J. Haskins; New York City.
Engineering Instruments.
R. Seelig & Son, Chicago.
Fire Proof Paint.
Detroit Graphite Mfg. Co., Detroit.
Forgings.
Cleveland City Forge & Iron Co., Cleveland, O.
Frogs and Crossings.
Indianapolis Switch & Frog Co., Springfield, O.
Frogs and Switches.
Amer. Frog & Switch Co.
Indianapolis Switch & Frog Co., Springfield, O.
Graphite.
Detroit Graphite Mfg. Co., Detroit.
Dixon, Jos., Crucible Co., Jersey City, N. J.
Hoes.
Hubbard & Co., Pittsburg, Pa.
Hoisting Machinery.
Wm. J. Haskins, New York City.
Inspection Cars.
Duntley Mfg. Co.
Fairbanks, Morse & Co., Chicago.
Light Inspection Car Co., Hagerstown, Ind.
Mudge & Co., Burton W.
Interlocking Switch Stands.
Foster, Frank M., Columbus, O.
Lamps & Lanterns.
Adams & Westlake Co., Chicago.
Light, Locomotive (See Locomotive Contractors.)
Jacks.
Dayton Iron Wks. Co., Dayton, O.
Fairbanks, Morse & Co., Chicago.
Watson-Stillman Co., New York.
Locomotives.
Cincinnati Equipment Co., Cincinnati, O.
Vulvan Iron Works, Wilkes-Barre, Pa.
Locomotives, Contractors'.
Hicks, F. M. & Co., Chicago.
Locomotives, Second Hand.
Hicks Locomotive & Car Works, Chicago.
Locomotive Replacers.
The Johnson Wrecking Frog Co., Cleveland, O.
Lubricants (Graphite).
Dixon, Joseph, Crucible Co., Jersey City, N. J.
Metal Paints.
St. Louis Surfacer & Paint Co., St. Louis, Mo.
Motor Cars.
Duntley Mfg. Co.
Fairbanks, Morse & Co., Chicago.
Mudge & Co., Burton W.
Oil Tanks.
Bowser, S. F., & Co., Ft. Wayne, Ind.
Paints.
Johnston Paint Co., R. F. Cincinnati, O.
St. Louis Surfacer & Paint Co., St. Louis, Mo.
Perforated Metal.
Dixon, Joseph, Crucible Co., Jersey City, N. J.
Picks.
Hubbard & Co., Pittsburg, Pa.
Pole Line Material.
Hubbard & Co., Pittsburg, Pa.
Post Hole Diggers.
Hubbard & Co., Pittsburg, Pa.
Pumps.
Bowser, S. F., & Co., Ft. Wayne, Ind.
Rail Benders.
The Industrial Supply & Equipment Co., Philadelphia, Pa.
Rail Braces.
Indianapolis Switch & Frog Co., Springfield, O.
Rail Drills.
Indianapolis Switch & Frog Co., Springfield, O.
Railroad Track Tools.
Hubbard & Co., Pittsburg, Pa.
Railway Equipment and Supplies.
Railway Supply Co., St. Louis.
Indianapolis Switch & Frog Co., Springfield, O.
Hicks Locomotive & Car Works, Chicago.
Replacers, Car, and Engines.
The Johnson Wrecking Frog Co., Cleveland, O.
Rolling Steel Doors and Shutters.
Adreon & Co., St. Louis, Mo.
Atlantic Equipment Co., New York.
Bird, F. W. & Son, East Walpole, Mass.
Stowell Mfg. Co., Jersey City, N. J.
Roofing Slates and Shingles, Asbestos.
Franklin Mfg. Co., Franklin, Pa.
Rolling Stock.
Hicks, F. M., & Co., Chicago.
Roofing Materials, Asbestos.
Franklin Mfg. Co., Franklin, Pa.
Sand Driers.
Parkhurst & Wilkinson, Chicago.
Second Hand Equipment.
Hicks Locomotive & Car Works, Chicago.
Sheathing, Asbestos.
Franklin Mfg. Co., Franklin, Pa.
Signal Lamps.
Adams & Westlake Co., Chicago.
Shovels, Spades and Scoops.
Hubbard & Co., Pittsburg, Pa.
Signal Specialties.
Brach Supply Co., L. S., New York.
Stock Guards.
Standard Cattle Guard Co., Birmingham, Ala.
Striking Hammers.
Hubbard & Co., Pittsburg, Pa.
Surveying Instruments.
R. Seelig & Son, Chicago.
Switches and Switch Stands.
American Valve & Meter Co., Cincinnati, O.
Indianapolis Switch & Frog Co., Springfield, O.
Frank M. Foster, Columbus, O.
Tanks and Tank Fixtures.
American Valve & Meter Co., Cincinnati.
Tie Plates.
Spencer Otis Co., Chicago.
Track Jacks (See Jacks.)
Track Materials.
Indianapolis Switch & Frog Co., Springfield, O.
Turnbuckles.
Cleveland City Forge & Iron Co., Cleveland, O.
Turntables.
Philadelphia Turntable Co. of Phila.
Washers.
Hubbard & Co., Pittsburg, Pa.
Water Columns.
American Valve & Meter Co., Cincinnati.
Water Softening Apparatus.
L. M. Booth Co.
Wedges.
Hubbard & Co., Pittsburg, Pa.
Wrecking Frogs.
The Johnson Wrecking Frog Co., Cleveland, O.
Wrenches.
Coes Wrench Co., Worcester, Mass.

RAILWAY ENGINEERING
AND MAINTENANCE OF WAY.

Vol. 6 No. 2. BRIDGES–BUILDINGS–CONTRACTING–SIGNALING–TRACK February, 1910

Contents

Railway Signal Standards

No. 2. The Rock Island Lines

The accompanying engravings illustrate present standard practice in the installation of automatic block signals on the Rock Island. At present this company is installing electro-motor signals with mechanism at base of post. Fig. 23, the standard signal, differs from the Railway Signal Association standard, in having but one arm. The character of the signal is indicated to an engineman by the shape of the blade and the presence of the number plate. The latter, Fig. 24, consists of a sheet iron plate fastened to clamps which hold it in place. The numbers are separate and enameled in white on a dark ground and are fastened by stove bolts to the plate.

The spectacle is similar in outline and of the same general dimensions as that shown in Fig. 9. The blade, Fig. 25, is made of white pine. All signals work in three positions and give indications in the upper right hand quadrant. For purely automatic block signals, normal clear circuits are used exclusively. The night color indications are—red, stop; yellow, caution; green, clear. A typical bracket post and signal are shown in Fig. 26. The same arrangement of signal is used on bridges. Where the signal has a mechanism case at the base of post, the top of the foundation is 18 inches above the top of rail.

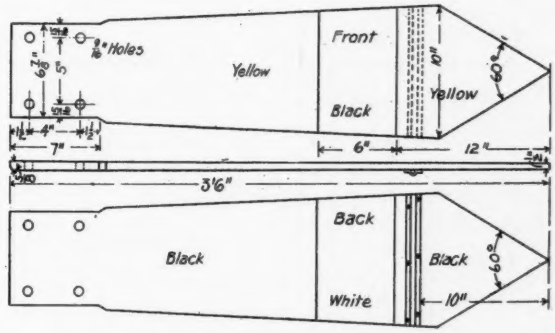


Fig. 25.—Automatic Block Signal Blade.

This arrangement is shown in Fig. 27, which also shows relation of other details to each other and to the track. The conduit which passes through the foundation as shown in Fig. 27 serves to lead the wires from trunking or other ducts into the case. The conduit is shown in detail in Fig. 28, and standard trunking in Fig. 29. Fiber conduit is also used to some extent.

Where the signal is on the same side of the track as the pole line wires are led into the case through a cast iron conduit

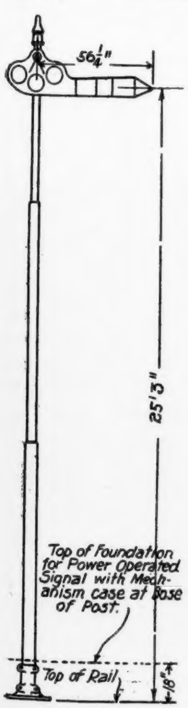


Fig. 23.—Automatic Block Signal on Ground Post.

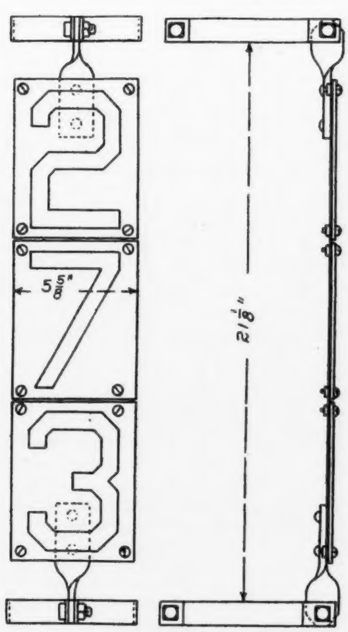


Fig. 24.—Number Plate for Automatic Block Signals.

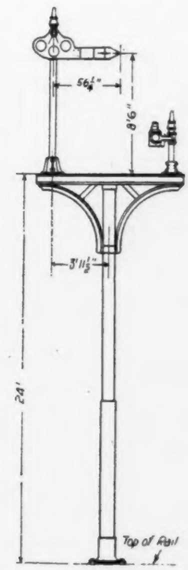


Fig. 26.—Automatic Block Signal on Bracket Post.

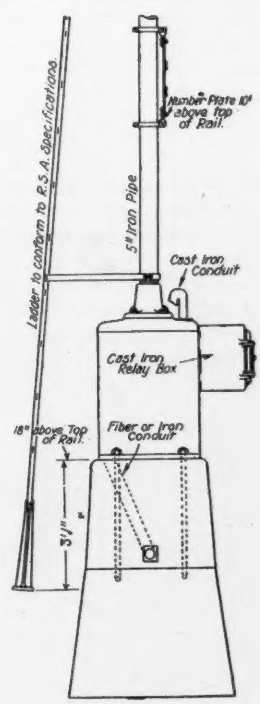


Fig. 27.—Automatic Block Signal on Concrete Foundation Showing Arrangement of Details.

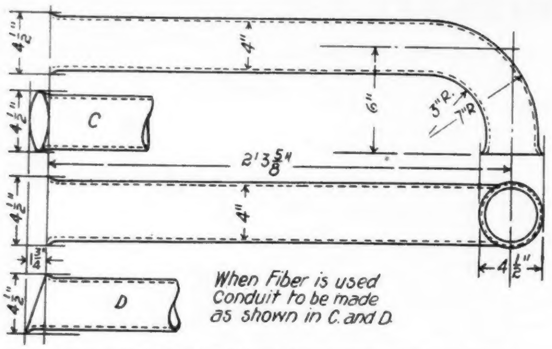


Fig. 28.—Conduit for Signal Foundation, Iron or Fibre.

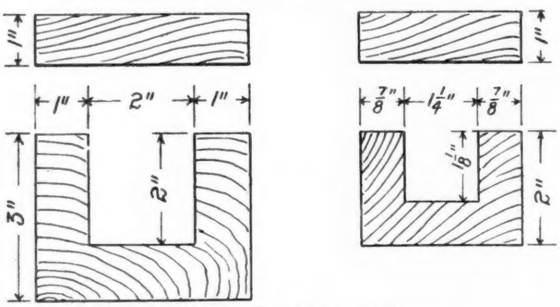


Fig. 29.—Wooden Trunking and Capping.

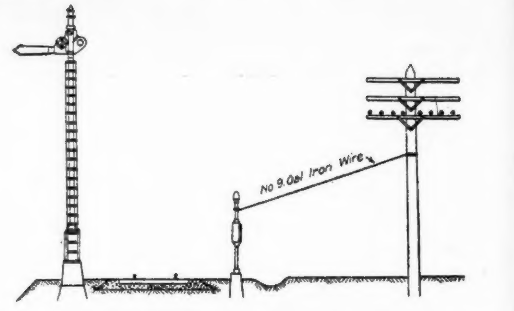


Fig. 31.—General Arrangement of Automatic Block Signal and Relay Box on Cable Post.

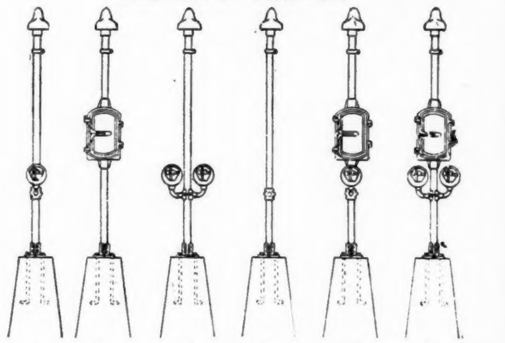


Fig. 32.—Cable Posts; A, with One Switch Indicator; B, with Relay Box; C, with Two Switch Indicators; D, Cable Post Only; E, with Relay Box and One Switch Indicator; F, with Relay Box and Two Switch Indicators.

screwed into the top of the case. This conduit appears in Fig. 27, and Fig. 30 shows the general arrangement; the wire being in a cable suspended from a messenger wire.

Where the signal is on the other side of the track from the pole line, a cable post with relay box is erected and the wires lead from the pole line to this, Fig. 31. The relay box, bolted to the mechanism case, shown in Figs. 27 and 30, is used when there is not sufficient room in the mechanism case to accommodate all the relays needed in certain situations.

On double track an indicator of the upper quadrant semaphore type is used at each switch to show the approach of trains. On single track two indicators are used in the majority of cases, one for each direction. A double indicator on a ground post is shown in Fig. 33. Fig. 32 shows how indicators are handled in connection with cable posts. In this figure are also shown relay boxes on cable posts. These posts are made of 3-inch iron pipe and are 9 feet high. They are mounted on concrete foundations. Wires from the pole line are always taken to a cable post or to the signal direct, Fig. 30.

Pole line details are shown in Figs. 34, 35, 36. Pins, insulators, cross arms, braces, etc., are Western Union standard. A separate pole line is not used for signal wires.

Wherever possible, wire ducts are placed above ground and are fastened to stakes. Figs. 37 and 38 show the arrangement of ducts at two typical situations and Fig. 39 shows the bootleg.

Fig. 40 shows how a switch is wired. At facing points the control circuit of the governing signal (45° to 90° indication on double track, 0° to 45° indication on single track, is taken through the switch box. The figure also shows standard arrangement of switch indicators.

The illustration of bonding, Fig. 41, switch rod insulation, Figs. 42, 43, tie plate insulation, Fig. 44 and ground rod Fig. 45, are sufficiently clear to need no comment except to say that bond wires are No. 9 B. W. G., E. B. B. galvanized iron, 44 inches long.

Signals are operated by batteries of 16 cells, caustic soda type, housed in concrete wells, Fig. 46, in northern territory or concrete boxes in southern territory. Track battery consists of 2 cells gravity in parallel, housed either in a chute, Fig. 47, of iron, fiber or concrete, or in the well with the operating battery. Track circuits vary in length from 1,500 feet to 3,500 feet, depending on the nature of the ballast. Line circuits are usually fed from a separate battery of 6 cells gravity. See Figs. 48, 49 and 50.

Figs. 48 and 49 are continuous with each other and show the arrangement of control circuits for signals and indicators on double track. It will be observed that a switch indicator is de-energized, showing the approach of a train, when the train is in the track circuit in the rear of the distant signal for the block concerned, and so remains until the train has passed out

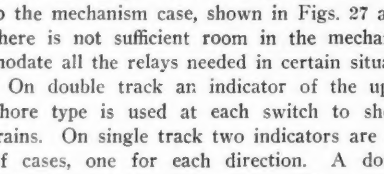


Fig. 30.—General Arrangement of Automatic Block Signal with Relay Box Bolted to Mechanism Case.

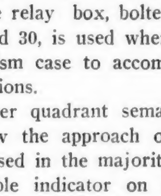


Fig. 33.—Two Switch Indicators on One Ground Post.

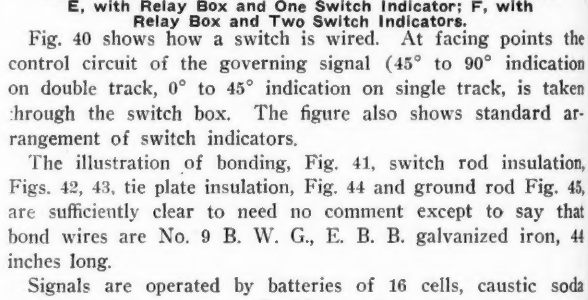


Fig. 34.—Junction and Intermediate Line Poles Showing Relative Positions of Wires and Method of Connecting to Cable.

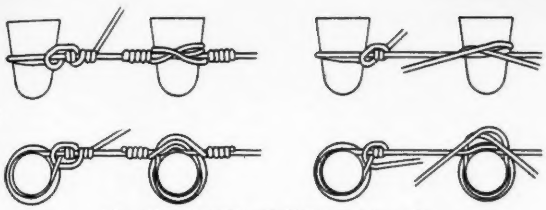


Fig. 35.—Method of Making Line Tie.

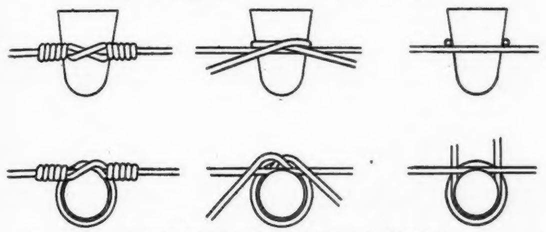


Fig. 36.—Method of Making Dead End Tie.

of the block. Lightning arresters are provided between the line and all instruments except switch boxes.

Fig. 50, circuits for signals on single track, shows standard control circuits. Here, as on double track, a separate line battery is used. It will be noted, however, that the line circuits are polarized; that is, the 45° to 90° position of the arm is controlled by a polechanger operated by the arm of the signal in advance. All polechangers work between 0° and 45° except those in the entering signals at stations on single track which work between 45° and 90° so that the "distant" indication of the outgoing signal is repeated back one extra block. The figure shows that common is overlapped between signals at each end of a station, thus breaking common twice for each station. The ground and lightning troubles due to long common wires are thus avoided.

The standard method of overlapping signals on single track is shown in Fig. 51. Laps at stations are unequal, the long lap being eastward in favor of inferior trains so as to allow such trains all the time possible to make a meeting point. Blocks on both double and single track vary in length, according to the

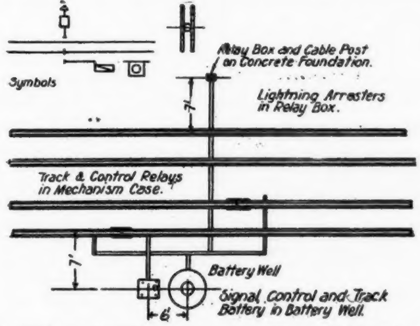


Fig. 37.—Layout of Trunking and Apparatus, Automatic Block Signal on Opposite Side of Track from Pole Line.

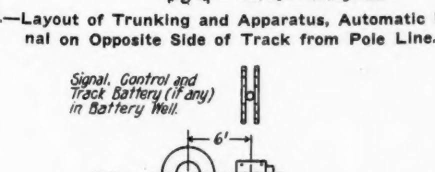


Fig. 38.—Layout of Trunking and Apparatus, Automatic Block Signal on Same Side of Track as Pole Line.

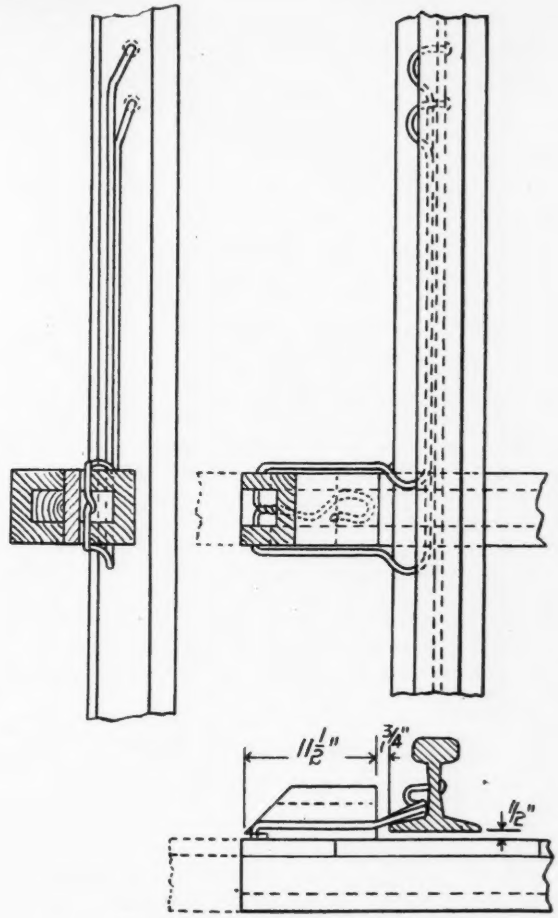


Fig. 39.—Bootleg, Rock Island Lines.

requirements of traffic. Indicators at switches on single track give the same information as on double track. Two methods of control are shown in Figs. 52 and 53.

In block signal territory all interlocking signals are power operated. Fig. 54 illustrates typical control circuits. These are so arranged that after a signal has been set at stop by a train it will not again clear until the lever controlling it has been put normal and again reversed. Circuits for a power operated distant signal with mechanical home are shown in Fig. 55.

Two sets of electric locking circuits are used, depending on how the lock is applied. They combine detector, approach and indication locking with minimum apparatus and maximum simplicity, Figs. 56, 57. One or the other of these is always used where interlocking plants occur in block signal territory.

The trap circuit, Fig. 58, is used where, due to crossing frogs or similar cause, an amount of dead track equal to or greater in length than wheel base of shortest car or engine, occurs. A car entering from either end will de-energize the stick relay.

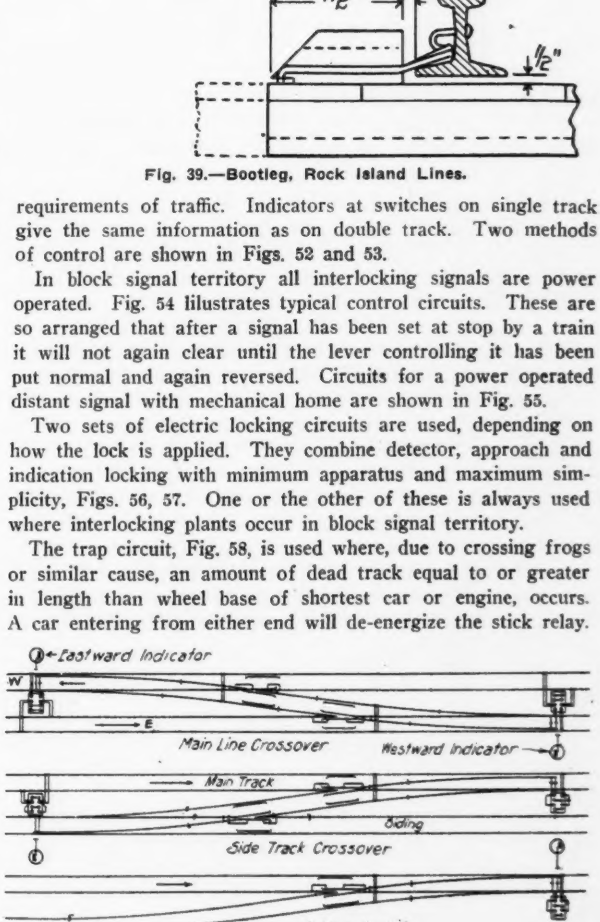


Fig. 40.—Switch Wiring for Trailing Points.

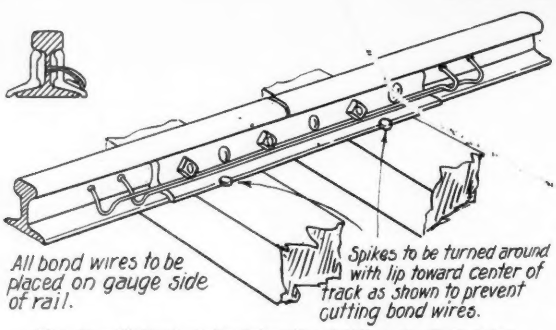


Fig. 41.—Method of Applying Bond Wires to Rail Joint.

This relay will remain de-energized until the last pair of wheels passes off the trap in either direction.

The following sizes and classes of wire are standard: Line wire, No. 10 B. & S. G., hard drawn weatherproof copper in northern territory; No. 12 of the same class in southern territory. From track to apparatus, No. 8 B. & S. G. rubber covered copper. Bootlegs Nok 6 B & S. G. rubber covered copper. From battery to mechanism, No. 8 B. & S. G. rubber covered copper. From line to apparatus, No. 14 B. & S. rubber covered copper. From line to apparatus, No. 14 B. & S. G. rubber covered copper, No. 12 for common. In chutes, No. 12 B. & S. G. rubber covered flexible copper. Relays used meet the R. S. A. specifications. Resistances, shown in Figs. 48-58, are as follows: track relay, 4 ohms; line relay, 50 ohms; switch indicators, 300 ohms.

Strengthening Bridges*

By P. A. Zahariade

The reporter, on the request of the Permanent Commission of the Railway Congress, dated 31 December, 1906, was selected by the administration of the Roumanian State Railway, to fulfill this funcction at the eighth session of the Congress, in his capacity as head of the Bridges department of the said railway.

In November, 1908, the reporter was transferred and became the Postmaster General of Roumania, but taking into consideration the advanced state of his report, he retained his function as reporter, with the consent of the government and of the administration of the Roumanian State Railway.

DETAILED LIST OF QUESTIONS.

1.—In general outline, what regulations have been issued since 1850, for securing the strength of iron railway bridges, especially those affecting limiting loads and the working stresses of the metal?

2.—What circumstances have directed the attention of administrations and companies to the necessity for revising the calculations of the strength of existing iron bridges, taking into account the date of their construction and the increase of rolling loads and of speed of trains?

3.—State shortly, what conditions have been taken into consideration in making this revision, as compared with those that would be taken account of when designing new structures of the same kind?

4.—When such a revision has been made, has it generally been necessary to make good any deficiency by means of strengthening existing structures or otherwise?

5.—What are the general features and the most important details of the strengthening works that have been planned and carried out on your railway system?

6.—What members of the structures, or what connections have you found it necessary to replace most frequently?

7.—To what special difficulties have these works given rise? What methods have been adopted, and what precautions have been taken to overcome these difficulties:

*Report in part from Bulletin of the International Railway Congress Association.

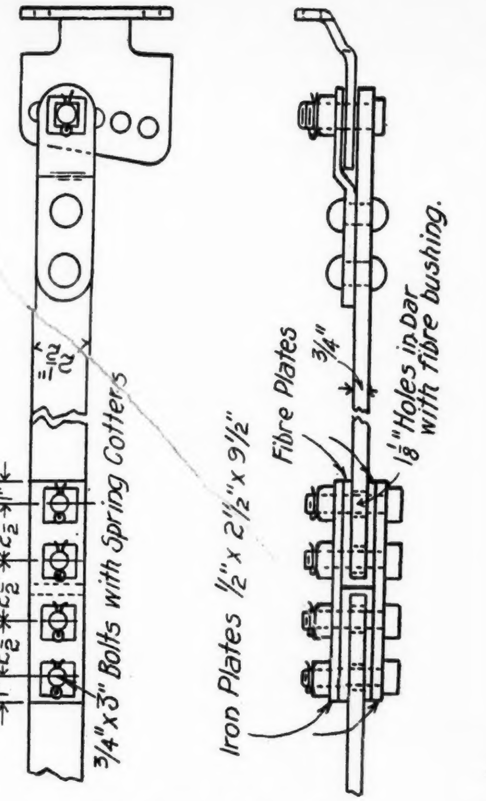


Fig. 42.—Insulated Switch Rod.

a) so as to ensure the complete success in the carrying out of the work, so as to secure the increase of strength that was required and intended,

b) so as to avoid interference with the working of the lines, and

c) so as to guarantee the safety of the traffic?

8.—What results have been obtained in testing such strengthened bridges in comparison with the anticipation of the design?

9—Taking into consideration, on the one hand, that almost all bridges requiring strengthening are of wrought iron, and on the other, that the employment of mild steel in metal structures in increasing more and more, what view has been taken, and what decisions have been come to as to the nature of the metal to be employed for strengthening bridges of wrought iron? In strengthening works, rather than maintain uniformity of metal, has it been thought better to obtain the increased strength by the use of mild steel?

10.—What do you estimate will be the average extra cost of metal used in strengthening works per unit of weight, due to the difficulties of execution inseparable from this kind of work, and to the restrictions necessary for keeping lines open for traffic?

11.—State your opinion, based upon a more or less polonged experience of what has been done on your system, as to the

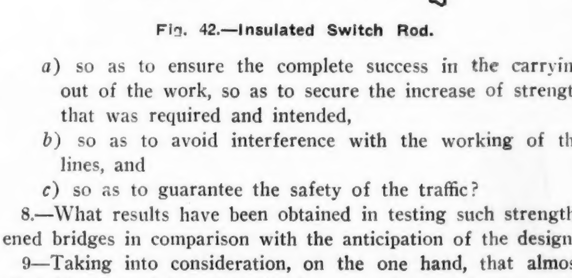


Fig. 43.—Fiber Plate and Bushing for Insulated Switch Rod.

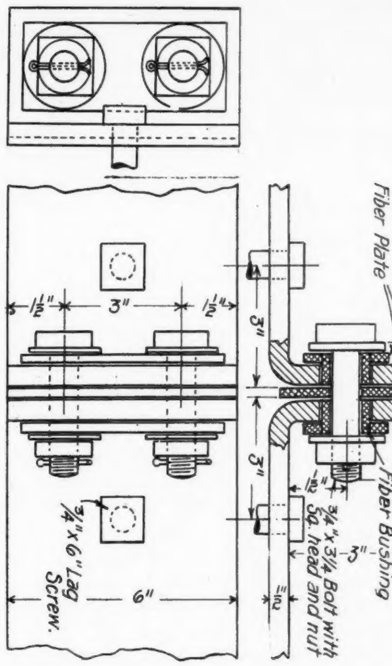


Fig. 44.—Insulated Tie Plate for Switches, Rock Island Lines.

lasting efficiency of strengthening works, and the ultimate increase of the cost of maintenance to which they may lead, as compared with that of unstrengthened structures of approximately similar capacity and design?

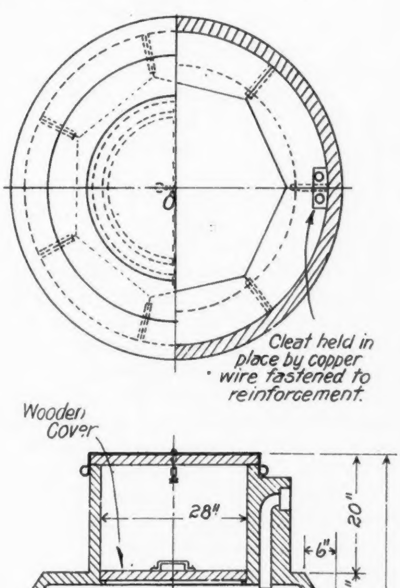


Fig. 46.—Concrete Battery Well, Rock Island Lines.

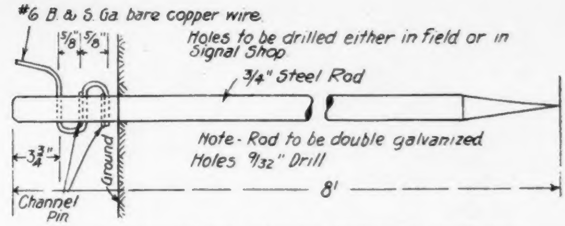


Fig. 45.—Ground Rod, Showing Method of Application.

12.—In what instances and for what reasons has it been thought advisable, instead of strengthening a weak bridge, to replace it with a new structure, either of metal, masonry or otherwise?

13.—Would it be advisable, and if so to what extent, to anticipate future increase of loads in excess of those applying at present either for the design of new bridges or for the strengthening of existing bridges?

The list of questions was sent to the railway administrations, belonging to the Congress, of the countries the reporter had to deal with.

Out of the six administrations, outside Roumania, three did not send any reply; two others have informed us that as their lines were of very recent construction, the question of strengthening the iron bridges had not yet arisen.

Finally, the administration of the Bulgarian State Railway

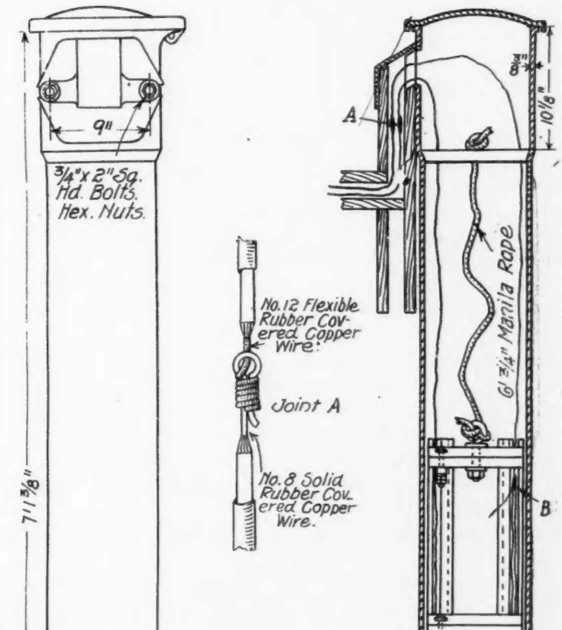


Fig. 47.—Battery Chute, Showing Wiring of Elevator and Method of Making Wire Joints, Rock Island Lines.

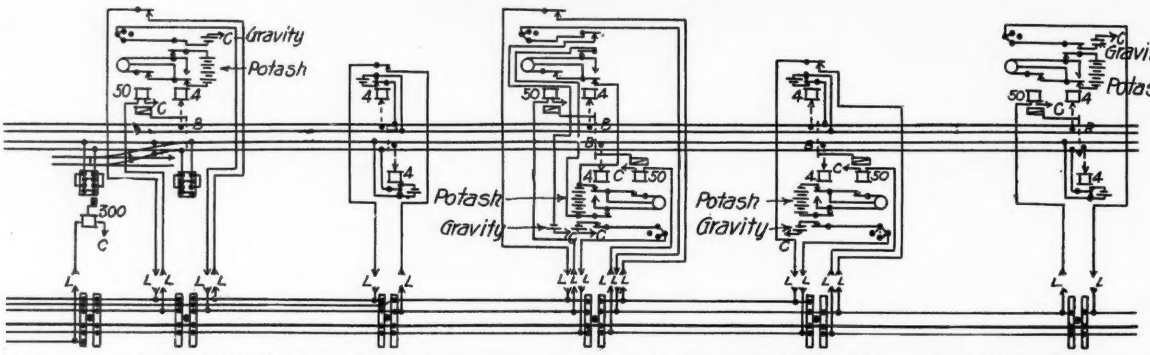


Fig. 48.—Automatic Block Signal and Switch Indicator Circuits for Double Track, Rock Island Lines. Note—When the track relay is de-energized, it cuts off both sides of the operating battery from the signal mechanism.

has informed us that it has had to replace the iron structure of some bridges, but only because inferior material had been used, while the increased weight of locomotives and speed of trains had not come into consideration.

Such being the case, our report is necessarily limited to work carried out in Roumania.

Nevertheless, we have thought it advisable to draw up our report, for such work has been of considerable importance and shows much variety.

In fact, since 1890, we have strengthened or replaced more than 8 kilometers (5 miles of iron bridges, at an expenditure of about 17 millions of francs (£680,000.)

I.—Official regulations for securing the strength of iron railway bridges.

The first railway lines in Roumania were built in 1869.

At that time, no government had as yet issued any regulations for securing the strength of iron railway bridges.

Moreover these lines, as well as all our other lines built before 1880, were constructed by concessionaries or by contractors and the corresponding specifications contained no provisions concerning the strength of the iron bridges.

Such being the case, and in the absence of official regulations, we are unable to ascertain on what principles the calculations for determining the strength of our iron bridges before 1877 were based.

After that date, we adopted, in succession, those regulations which seemed to us most rational; thus from 1877 to 1887, we used the regulations of the French circular of 1877; from 1887 to 1892, those of the Austrian order of 1887; after 1892 the Swiss regulations of 1892 were adopted, at first partially and combined with the prescriptions of the Austrian order, finally completely and without restriction.

Finally, since 1904, we are using the Prussian prescriptions of 1903.

All these regulations and prescriptions are sufficiently well known and contain all the details desirable, concerning the loads and the stresses the material is subjected to; it is therefore useless to give any further particulars on the subject in this report.

II.—Circumstances leading to the revision of iron bridges.

From 1890 onwards, numerous defects were found to exist in the iron structures of our railway bridges and were reported by the permanent-way engineers.

This circumstance, together with the nearly entire absence of drawings and of strength calculations of the bridges built by the concessionaries, and also our uncertainty as to the quality of the material used in their construction, led us to undertake a minute examination of the iron structure of our bridges and a revision of the strength-calculations, taking into account the continual growth of the rolling loads.

When after the Moenchenstein accident (1891), nearly all railway administrations recognized the need of making further provision for ensuring the safety of the traffic, the revision work which we had commenced the year before, was pushed on more energetically. The order which had been issued, prohibiting double-headed trains from passing over bridges which had been found too weak, was extended to all iron bridges before 1890, even if the calculations of those bridges had not yet been revised, for the weight of the heaviest locomotives used, which had at the start been 28 tons (49 tons with tender) with an axleload not exceeding 10 tons, had gradually increased till it had attained, in 1890, 50 tons (76 tons with tender), with a an axle-load of 14 tons.

Today we have locomotives weighing 72 tons (110 tons with tender), with a maximum axle-load of 15.5 tons.

III.—Arrangements made for the revision of the iron bridges.

In order to proceed methodically, it was necessary, in the first place, to draw up a list of all the existing bridges and to classify them according to type and span.

Then measurements were taken of the metal structures and of all their constituent parts. This made it possible to complete and correct any drawings which were defective, and to make fresh drawings in cases where there were none.

At the same time, any constructive or other defects which could be discovered were recorded.

Finally, on the basis of the information so accumulated, fresh calculations of strength were made according to the prescriptions in force, at the time being, for new bridges.

IV.—Necessity of strengthening and other work.

The revision of the calculations showed that the strength of all the bridges built before 1890 was too low, not only according

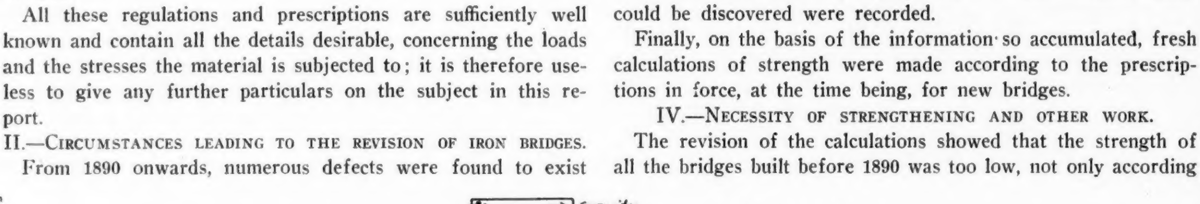


Fig. 49.—Automatic Block Signal and Switch Indicator Circuits for Double Track, Rock Island Lines.

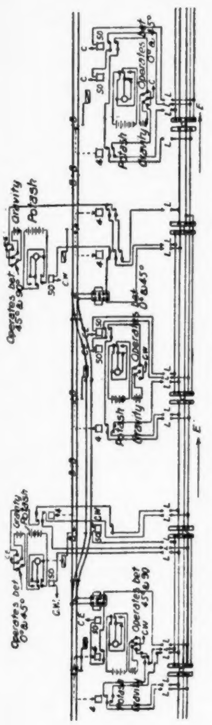


Fig. 50b.—Automatic Block Signal Circuits for Single Track.—Two Track Circuits at Station—See note under Fig. 48.

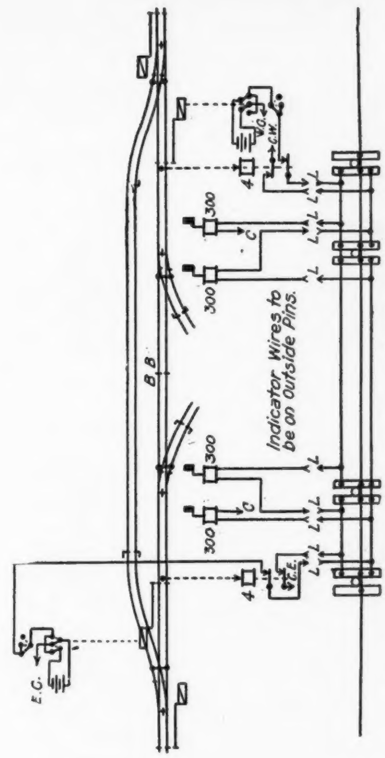


Fig. 53.—Switch Indicator Circuits for Single Track—One Track Section at Station, Rock Island Lines.

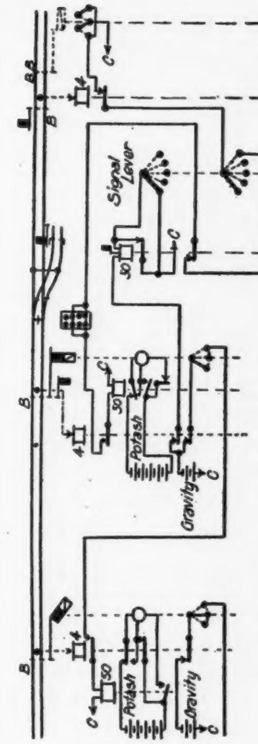


Fig. 54.—Circuits for Power Operated, Semi-Automatic Signals at Mechanical Interlocking Plant with Block Indicator, Rock Island Lines.

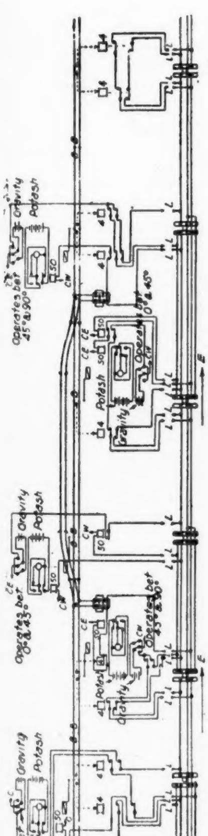


Fig. 50a.—Automatic Block Signal Circuits for Single Track—One Track Circuit at Station, Rock Island Lines.

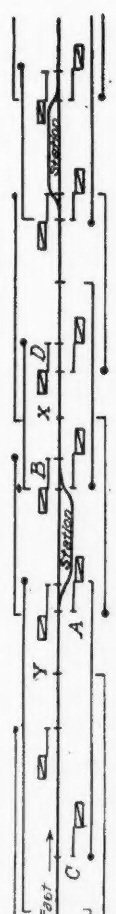


Fig. 51.—Overlaps for Automatic Block Signals on Single Track, Rock Island Lines.

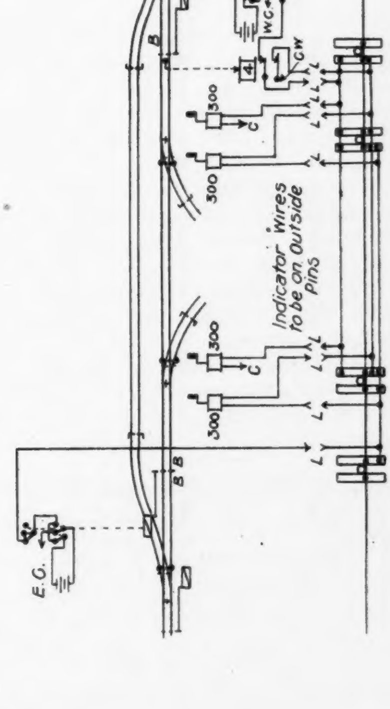


Fig. 52.—Switch Indicator Circuits for Single Track with Cut Section at Station, Rock Island Lines.

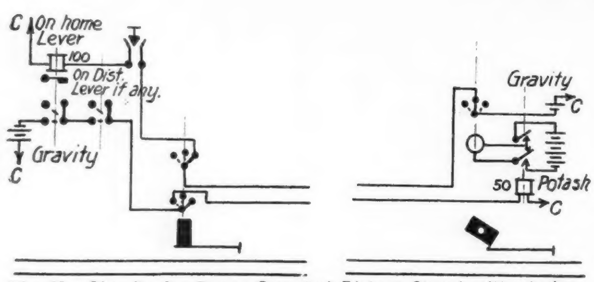


Fig. 55.—Circuits for Power Operated Distant Signal with Mechanical Home Signal, Rock Island Lines.

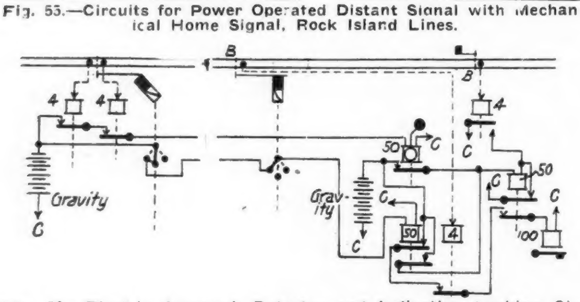


Fig. 56.—Electric Approach Detector and Indication Locking Circuits with Annunciator: Lock on Lever Other than that Controlling the Signal, Rock Island Lines.

to the prescriptions of the Austrian order of 1887, but also because the metal was subjected to more than the permissible stresses even if only the rolling loads existing at the time were taken into consideration.

It was found, in isolated cases, that parts were subjected to stresses of 1,800 and even 2,000 kilograms per square centimetre (11.43 and even 12.70 English tons per square inch).

This state of affairs was due not only to the increase in the weight of the locomotives, but also to the defects in the old specifications on which the calculation of strength was based.

Moreover, the old iron structures were not always designed rationally.

Finally, the detailed inspection of the work enabled us to discover numerous existing defects in the metal work of our iron bridges.

Thus parts were considerably out of level; main girders were out of true; parts, particularly of the lattice work, were wrong; the thickness of webs and other parts was too small; there were defective or missing joints, etc.

A very common fault in construction was having the rivets too near the edge of the parts they held together; this produced numerous cracks in those parts and consequently materially weakened the effective cross-section.

This state of affairs was very disquieting and compelled us at once to take measures to remedy the defective strength of our iron bridges.

V.—GENERAL SCHEME AND DETAILS OF THE STRENGTHENING WORKS.

The many strengthening works which have been carried out on our railway system can in spite of their great diversity, be referred to several principal types, namely:

a Strengthening by the addition of flats, flat bar, angle-iron, or other rolled sections of iron or of mild steel, in order to strengthen existing members;

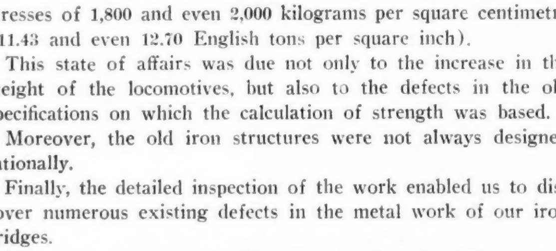


Fig. 57.—Electric Approach Detector and Indication Locking Circuits with Annunciator; Lock on Signal Lever, Rock Island Lines.

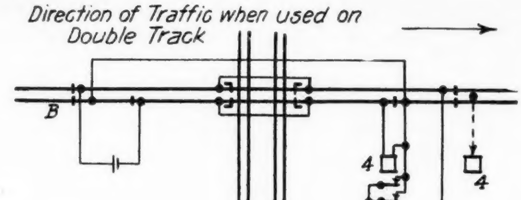


Fig. 58.—Trap Circuit, Rock Island Lines.

b Strengthening members as above, and adding new ties, etc.;

c Strengthening by the introduction of a relieving arch;

d Strengthening by supplementary the existing girders by extra girders to transfer the excess of load to the later;

e Indirect strengthening by the construction of intermediate supports.

The earlier strengthening works we undertook were carried out according to either plan *a* or plan *b*.

In such cases, in order to strengthen members, we have, as a rule, added new flanges.

But in order to avoid, as far as possible, the taking out of existing rivets, we have in many cases adopted other solutions.

Thus we have strengthened solid-rivet girders by adding angle-iron fixed to the web, so as to form members of a double-channel section] [; or in the case of lattice girders with T members, and when enough space was available, we fixed the extra angle-iron below the projecting edges of the large flats.

When the track was laid direct on the main lattice-girders, we have introduced sleeper girders and stringers.

The upper members, relieved in this way from the stresses produced by the direct deflection of the different sections, did not, as a rule, require to be strengthened.

As regards lattice work, we have whenever possible preferred, to direct strengthening, the introduction of new sets of diagonals.

The strengthening of girders with simple N lattices could easily be effected, in this way, by the addition of another system of lattice bars working in compression, which relieved the original lattice bars of half the stresses produced by the rolling load, and reduced the stresses in the uprights to one half.

Under this system of strengthening, simple-lattice girders became double-lattice girders, and double-lattice girders became quadruple-lattice girders.

In the case of certain girders having a great depth, and with not enough lattice work to give them sufficient stiffness, we added stiffeners.

We proceeded in the same way, at the same time strengthening, if necessary, the existing uprights, if they were too far apart.

In addition, all the joints were carefully examined, and if defective, the necessary rivets and gussets were added.

When the construction made this possible, we added pieces of angle-iron secured, by the additional number of rivets necessary, on the one side, to the web of members and on the other, to the available flanges of the angle-irons or sections forming the lattice-work.

As a general rule, it was necessary to strengthen, besides the main girders, also the wind bracing, the sleeper girders, the stringers and their fastenings.

The bars of the wind bracing of the old bridges being generally formed of flats of insufficient strength, we replaced them by angle-irons so as to give them, in addition to the strength required, also a certain stiffness.

Moreover, while the strengthening work was carried out, all the parts which were found faulty were taken out and replaced by new.

But the strengthening carried out according to the above plans *a* and *b,* is only possible when the amount of iron which has to be added does not exceed a certain limit.

Taking into consideration the difficulties attending the strengthening of existing bridges, and the continual interruption of work when trains pass, we assumed, *a priori,* that the cost of a ton of iron in this kind of work would be twice that of a ton of iron used in the case of a new iron bridge; and experience has confirmed this.

That being so, it is only profitable to strengthen a bridge of insufficient strength, if the quality of iron to be added is less than half the weight of a new bridge; for if the cost is equal, it is decidedly better to build a new bridge than to strengthen one already in use.

Moreover, the work of strengthening hampers the traffic to a considerable extent.

In order to allow for the losses resulting from this cause, we decided only to retain and strengthen those bridges in which the amount of iron to be added did not exceed one-third of the weight of a new structure.

While only the prescriptions of the Austrian order of 1887 were applied, it was possible to carry out the strengthening of the existing bridges on this plan.

But after the Swiss prescriptions of 1892, and still more after the Prussian ones of 1903, had been adopted, not only did the quantity of iron to be added exceed the limits admissible, but insuperable difficulties arose in planning the strengthening work.

It then became necessary to adopt other measures, and even to replace, by new iron bridges, a large number of bridges which could easily have been suitably strengthened on the bases of the Austrian order of 1887.

In this way, we strengthened a large number of bridges, both according to plans *a* and *b,* and plans *c, d* and *e* mentioned above.

The reasons which led to the selection of a solution, as well as the particular character of each work, vary so much that it is difficult, if not impossible, to generalize; therefore, in completing this chapter, we think it better to give the description of sundry strengthening works carried out on our railway system, selected from the most characteristic cases.

As the drawings and photographs annexed to this report are very detailed, it would be superfluous to extend this description beyond the details which are not clearly shown on those reproductions.

VI.—Faulty parts.

We cannot state definitely what members or parts have had to be strengthened more frequently or in greatest number, for in most of the bridges which we have had to strengthen, we have generally had to strengthen, not only the main girders, but also the wind bracing, the sleeper girders, and the stringers, together with their fastenings; that is to say, all the parts of the iron structure of these bridges.

VII.—Difficulties encountered in the strengthening works and means taken to overcome them.

The difficulties which arise during strengthening works are greater or less according to the system of strengthening adopted.

The system which consists in the addition of plate, angle-iron, etc., to reinforce existing members, is that which presents the most serious disadvantages as far as the safety of the traffic is concerned, as a large number of rivets have to be taken out.

It is evident that if stagings were erected, to carry both the load and the weight of the structure which is being strengthened, this disadvantage would be overcome and the work could be carried on without interruption and in perfect safety.

But the advantages of this solution would be much outweighted by the expense which such an installation would entail.

Moreover, with this system, great and continuous care is required to avoid any possible displacement of level of the girders, and consequent uncertainty as to the resulting strains.

It is thus becoming necessary to carry out leveling operations at frequent intervals, and to examine the packing carefully before and after the passage of each train and to readjust it if necessary, and this makes the supervision of the work a very complicated matter.

On account of these reasons, we never adopted this method, and it was only very rarely that we supported, temporarily, certain girders, and then only at the middle of the span, when it was necessary to take out a large number of important rivets; for instance, in the case where we had to add new flanges to the members, and the cross-section left was too small to resist the stresses resulting from the weight proper.

Under such conditions, it is clear that the iron added only comes into play when the bridge is acted on by the rolling load, and that, consequently, the strains produced in the different parts of unstrengthened bridges by the weight proper, are not reduced by the increased area given to the cross-sections of those parts.

Another disadvantage consists in the necessity of interrupting the work during the passage of trains.

In the case of a through bridge, it is moreover necessary to remove the staging, and this has led us to devise movable staging which could easily be removed when the trains approached.

As a measure of precaution, we as a rule strengthened the main girders first, and then dealt with the bridge platform and the roadway subsequently, so as not to overload, uselessly, girders which were already too weak.

We also arranged matters so as never to take out all the rivets of a connection at once, and any rivet taken out was replaced by a bolt and nut, properly secured, or by a pin, before the passage of a train.

Finally, all the trains had to slack when approaching bridges which were being strengthened, so that it was possible, in case of necessity, to stop them before they reached the bridge.

In the case of bridges strengthened by other methods, no special precautions are required.

VIII.—Results of tests.

The results obtained by testing the strengthened bridges have been entirely satisfactory.

The deflections measured directly were generally less than those given by the theoretical calculations, and the use of the Manet and Rabut apparatus for the direct measurements of the stresses, has proved to us the agreement between the results obtained and the anticipations of the design.

IX.—Nature of the metal used.

At first we used wrought iron in strengthening our bridges.

But as soon as manufacturers began to supply mild steel at a moderate price, and even at a lower price than wrought iron, we did not hesitate to use it, although all the bridges we had to strengthen were made of rolled wrought iron; and consequently the greater strength of the steel was not utilized.

X.—Cost of the strengthening works. . .

The cost of a ton of iron put into place, in strengthening works, has amounted on the average to 1,000 francs (£40), that is to say, to approximately twice that of a ton of iron used in a new structure, which amounts to about 500 francs (£20).

In the case of strengthening works, which consisted in the addition of new structures, the cost has not materially exceeded that of iron used in new structures.

XI.—Efficiency of strengthening works.

Our experience, gained during more than eighteen years, during which we have been continually engaged on such strengthening works, enables us to state that the results obtained have been most satisfactory, and that a bridge strengthened under suitable conditions is in no way inferior to an original structure of the same strength.

As during the strengthening work, all the parts which were found to be faulty were repaired or even renewed, with the greatest care, there has even resulted an appreciable reduction in the cost of maintenance.

As a rule, the maintenance is reduced to painting operations.

XII.—Selection of a solution.

When the necessity of strengthening the iron structure of certain bridges has been recognized, the first question which naturally arises is, whether it is better to strengthen them or to rebuild them.

But the considerations which affect the selection of a solution are so numerous, and vary so much in every individual case, that it is impossible to lay down general rules for the solution of the problem.

For it not only has to be decided, whether a bridge is to be strengthened, but also how the strengthening is to be effected.

This question has been sufficiently considered in the fifth chapter of this report, and the work in connection is so varied that it includes almost all the cases possible, so it is unnecessary to reconsider it here.

If renewal is decided on, it is equally necessary to consider the different solutions which may be possible.

Thus, if the masonry work is in good condition, it is, as a rule, only necessary to replace the defective structure by a new iron structure; this is an easy piece of work which can be carried out without interfering with the running of the trains and without affecting their safety, for in such a case the new structure is erected, next to the old one, on a special staging, without touching the bridge in use.

After the new structure has been put up and the new track (sleepers and rails) laid, the two structures are moved laterally.

In this way, the old bridge is moved on to a staging prepared, for the purpose, on the side of the line opposite to that on which the new bridge has been erected, while the latter is brought to the place previously occupied by the old bridge which it is to replace.

This operation which at first was looked upon with a certain apprehension, is easily carried out in practice.

The moving is effected by means of a track formed of a suitable number of parallel rails, well greased, on which is placed a framework supporting the new structure; this also consists of rails, but turned upside down so that the rolling surfaces of the rails slide on each other.

We found this system very satisfactory and prefer it to all other systems, because it is simple and safe, and because it also makes it possible to give a movement in the longitudinal direction of the bridge, and this is often necessary to get it in exactly the right position on the supports.

We have only exceptionally used roller trucks (rollers with double flanges) and we gave this up, because unless complicated and expensive roller trucks were used, it was impossible to avoid an unequal distribution of the load on the rollers, which might easily produce fractures or make the rollers jam.

Moreover, if trucks are used, the rails on which they are used have to be laid with great accuracy, for no longitudinal movement is possible without supplementary installations and operations, which unnecessarily lengthen the time during which the running of the trains has to be suspended.

The only advantage which results from the use of trucks is that the amount of power required to shift the bridge is materially reduced, but this is not important enough to lead to the rejection of the other system, for the force required can easily be obtained by means of jacks and tackle.

Moreover, experience has shown that if everything is ready and prepared in advance, the moving does not take longer than ten to fifteen minutes, even in the case of large spans.

The total time required for raising the old structure, removing the lifting gear, placing it on its slides, moving both structures, old and new, lowering the new structure on to its supports, joining up the track at both ends of the bridge, and making the rolling-load tests, does not exceed from an hour to an hour and a half.

When the masonry work of a bridge is insufficient, either because it is in bad condition, or because its dimensions are too small, or because the foundations are doubtful, and when consequently a complete reconstruction is necessary, it is advisable to consider the question of a new masonry bridge, particularly when, owing to local conditions, the position of the new bridge is varied, for in most cases the height necessary is not available.

In all the cases which may arise, it is of course necessary to consider the question of cost, not in an absolute manner, but taking into consideration the circumstances which might eventually be in favor of an apparently more costly solution.

Taking it altogether, in the case of bridges of small span we have preferred, to strengthening them, to replace them by new iron structures or by masonry or reinforced concrete bridges.

When such old iron structures were in good condition, we utilized them, after they had been strengthened at the workshop, for replacing other bridges of the same span. In some cases, we proceeded in the same way with the stringers of some bridges and even with the sleeper girders.

We have also replaced, by new structures, all the iron bridges which showed serious defects or improper construction, and finally those which could not be strengthened rationally.

XIII.—Arrangements made with a view to the future.

It is evident that in order to meet the growing demands of the traffic, the power of locomotives will be increased more and more, and consequently it is necessary to take into ample consideration the certain increase in the rolling loads.

But it is certain that the rolling loads provided for in the Prussian prescriptions of 1903 (which we adopted when they were published) both concerning new bridges and the strengthening of existing bridges, will not be attained with us till in a very distant future.

For those prescriptions take into consideration locomotives weighing 85 tons (124 tons with tender), with a maximum axle-load of 17 tons, and as this weight is greater than most of our tracks can carry, there can be no question of exceeding this limit without at the same time rebuilding the tracks.

In such a case, the question will then arise, whether this tendency of the locomotive department justifies the very large expenditure which the strengthening of the bridges and the reconstruction of the track would involve.

On the other hand, it may be hoped that the application of electric traction, as well as the continual progress which is being made in internal-combustion motors, will modify the existing type of locomotive.

Under these conditions, we do not think it is necessary to go beyond the provisions of these prescriptions.

XIV.—Conclusions.

1.—In the case of bridges of small span, it is, as a rule, preferable to replace them by new structures;

2.—The system of strengthening which consists in the addition of plate, angle-iron, etc., in order to strengthen the cross-section of existing bars is only to be recommended if the additions do not exceed a certain limit and if they are easy to make;

3.—Strengthening by the addition of new members to existing structures is generally an advantageous solution;

4.—Mild steel is used in current practice in strengthening work;

5.—It is difficult to fix a general limit as regards the future increase of rolling loads, but we are of opinion that the Prussian prescriptions of 1903 may be considered as satisfying the requirements of the traffic for a long time to come.

Maintenance of Way Association:

A meeting of the Board of Directors of the American Railway Engineering and Maintenance of Way Association was held in New York on Tuesday, January 18th, and the following were nominated for officers for the current year:

For President—L. C. Fritch, Chief Engineer, Chicago Great Western Railway

For Vice-President—Chas. S. Churchill, Chief Engineer, Norfolk & Western Railway.

For Secretary—E. H. Fritch.

For Treasurer—Chas. F. Loweth, Engineer and Superintendent Bridges and Buildings, Chicago, Milwaukee & St. Paul Railway.

For Directors—(Three years each)—F. S. Stevens, Superintendent, Philadelphia & Reading Railway; Robert Trimble, Chief Engineer Maintenance of Way, Northwest System, Pennsylvania Lines west of Pittsburg.

The Railway Business Association

It is now sixteen months since the manufacturers of equipment, material and supplies organized the Railway Business Association. With characteristic energy and enthusiasm, the members of this craft have responded to every call, and gone after the desired result with the same determination and optimism that they are accustomed to display in their business. The members of the general executive committee have given ungrudgingly of their time and thought for consultation, many of them having to travel long distances to attend the conferences. The plans mapped out by the committee and suggested to the membership have been eagerly seized and carried out in a way that makes success certain.

In view of the cordial reception accorded by the public and by legislative bodies, the question now most often asked is why this vast economic force did not sooner band together in its own interest. It has made men think, it has encouraged caution and wisdom both as to ways of regulating and as to ways of explaining proposed measures which those to be regulated may regard as unwise. All this the association has done without calling names or questioning motives. It has regarded its function as that of promoting good nature. Salesmen, it is pointed out, are trained in the art of friendliness. The Railway Business Association has endeavored to become a sort of "Smile Combine."

George A. Post.

The railway officials had nothing to do with forming the association and contribute nothing to its treasury or its management. They early appreciated that any influence which the supply craft might exert would depend upon maintaining entire independence of the railroads. The manufacturers have a different training from that of the railroad official, and have a point of view of their own derived from their commercial necessities and experience as to how difficulties are best met and overcome. They have gone right at the problem of railroad regulation just as they have been accustomed to encounter problems in their own business by going and seeing the other fellow, making his acquaintance, gaining his confidence and asking nothing that was not fair.

The technical discussion of specific bills they leave to the railroad managers. The manufacturers point out that there is a widespread and growing disposition of the carriers to acknowledge the desirability of regulation and a frank and open attitude in stating facts as to the probable effect of proposed restrictions. This attitude they ask the legislators to welcome, which they are doing; and, as a member of the association, would put it to "Find out whether the bill would reduce the ability of the railroad to buy our goods."

We present portraits of some of the gentlemen whose names appear on the following list of officers of the association:

President.

George A. Post, President, Standard Coupler Co., 2 Rector St., New York City.

Vice Presidents.

H. H. Westinghouse, V. P., Westinghouse Air Brake Co., 165 Broadway, New York City.

O. H. Cutler, Pres., American Brake Shoe & Fdy. Co., 32 Cortlandt St., New York City.

W. H. Marshall, Pres., American Locomotive Co., 30 Church St., New York City.

E. S. S. Keith, Pres., Keith Car & Mfg. Co., Sagamore, Mass.

A. H. Mulliken, Pres., Pettibone, Mulliken & Co., 725 Marquette Bldg., Chicago, Ill.

O. P. Letchworth, Pres., Pratt & Lechtworth Co., Buffalo, New York.

W. G. Pearce, V. P., Griffin Wheel Co., 600 West Union Bldg., Chicago, Ill.

Treasurer.

Charles A. Moore, Pres., Manning, Maxwell & Moore, Inc., 85 Liberty St., New York City.

Secretary.

Frank W. Noxon, 2 Rector St., New York City.

Executive Members.

Col. H. G. Prout, V. P., Union Switch & Signal Co., Swissvale, Pa.

J. S. Coffin, Pres., Franklin Railway Supply Co., 30 Church St., New York City.

E. L. Adreon, V. P., American Brake Co., St. Louis, Mo.

J. H. Schwacke, 1600 Hamilton St., Philadelphia, Pa.

A. M. Kittredge, Pres., Barney & Smith Car Co., Dayton, Ohio.

Major John F. Dickson, Pres., Dickson Car Wheel Co., Houston, Texas.

W. B. Leach, G. M. & Treas., Hunt-Spiller Manfg. Corp., 383 Dorchester Ave., Boston, Mass.

Alba B. Johnson, V. P. & Treas., Baldwin Locomotive Works, 500 No. Broad St., Philadelphia, Pa.

E. B. Leigh, Pres., Chicago Ry. Equipment Co., 46th St., Chicago, Ill.

James Viles, Treas., The Buda Company, 637 Ry. Exchange Bldg., Chicago.

W. E. Clow, Pres., James B. Clow & Son, 342 Franklin St., Chicago, Ill.

H. Elliot, Pres., Elliot Frog & Switch Co., East St. Louis, Ill.

W. O. Dodd, Pres., Natl. Lock Washer Co., Newark, New Jersey.

W. H. Whiteside, Pres., Allis-Chalmers Co., Milwaukee, Wis.

W. H. Miner, Pres., W. H. Miner Co., Chicago.

Oliver Crosby, Pres., American Hoist & Derrick Co., St. Paul, Minn.

W. P. Worth, Treas., Worth Brothers Co., Coatesville, Pa.

RAILWAY ENGINEERING
AND MAINTENANCE OF WAY.
BRIDGES-BUILDINGS-CONTRACTING-SIGNALING-TRACK

W. H. Marshall.

Frank W. Noxon.

O. H. Cutler.

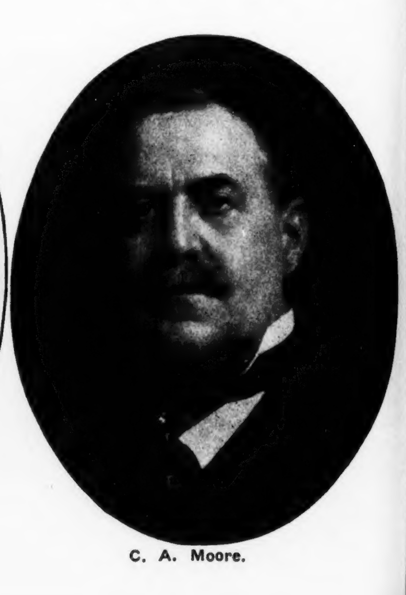
We publish below a few short biographical sketches of those who have helped make the Railway Business Association what it is:

George A. Post, the president, is also president of the Standard Coupler Co. of New York. He was born Sept. 1, 1854, at Cuba, Allegheny county, N. Y. His youth was spent at Owego, Tioga county, N. Y., and his education obtained in the public schools, the Owego Academy and the Oswego Normal school. Removing to Susquehanna, Pa., at 18, he entered the freight service of the Erie R. R., subsequently becoming assistant to the superintendent of motive power. For about 10 years Mr. Post was actively identified with politics as a democrat. He was elected mayor of Susquehanna at 22, candidate for presidential elector at 26, and elected a member of the 48th Congress in 1882 at 28, being the youngest member of that body. While in the employ of the Erie R. R. he read law nights and was admitted to the bar of the Supreme Court of Pennsylvania. For several years he was a member of the democratic state committee and chairman of the Susquehanna county committee, was a delegate to the National convention of 1884 and chairman of the state convention of 1885. He was secretary of the democratic Congressional committee in 1886. Mr. Post was editor and part owner of the Democrat, published at Montrose, Pa., from 1883 to 1889, when he moved to New York, where for two years he was connected with the World. In 1892 he entered the railway supply business as vice-president of the Standard Coupler Co., of which since 1894 he has been president. After 10 years devoted wholly to business life, Mr. Post in 1904 was chairman of the Executive Committee of Railway Supply Manufacturers in connection with the conventions of the Master Car Builders and the Master Mechanics, and was active in effecting the permanent Railway Supply Manufacturers' Association in 1906. In 1905 he was chairman of the American Railway Appliance Exhibition in connection with the International Railway Congress at Washington, D. C., an event which made the railway supply craft more prominent than ever before. Mr. Post in 1908, together with Charles A. Moore, Otis H. Cutler and J. S. Coffin, signed the call which resulted in the formation of the Railway Business Association. He became its first president and is now serving his second term. He is vice-president of the Machinery Club of the city of New York, and a member of the Council of the Pennsylvania Society of New York. He lives at Orange, N. J.

Frank W. Noxon, the secretary, has had an extended experience in newspaper work, both as editor and special contributor. He has been engaged for about 15 years in newspaper work in

E. S. S. Keith.

A. H. Mulliken.



C. A. Moore.

O. P. Letchworth.

E. L. Adreon.

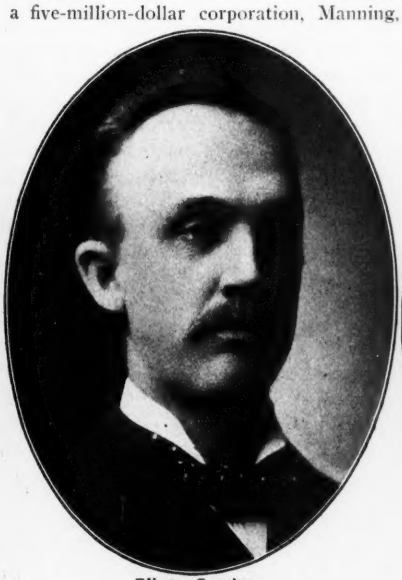
J. S. Coffin.

Boston, having been connected with the Advertiser, Traveler and Herald, where he did able and effective work in connection with public movements, on which he has won high encomiums from important people. He began writing for the Herald, in Syracuse, his birthplace, in 1892.

Alfred H. Mulliken, vice-president, was born in Augusta, Me. He came to Chicago and entered the service of Crerar, Adams & Co. as office boy in 1868. He started a railway supply business in 1880 which was sold to Crerar, Adams & Co. in 1885. Mr. Mulliken then engaged in the manufacture of track tools, frogs and switch material. His work since is well known history of the firm of Pettibone, Mulliken & Co. one of the largest manufacturers of frogs and switches in the world.

Charles A. Moore, treasurer, was born at West Sparta, N. Y. During the civil war he served in various capacities in the United States Navy, and later went to Boston, where he engaged in the business of selling engineering specialties. In 1880, having secured control of the business of the Ashcroft Manufacturing Co. and the Consolidated Safety Valve Co., he brought the business to New York, moving the factories to Bridgeport Conn., and combined these interests with those of H. S. Manning & Co., forming the well-known firm of Manning, Maxwell & Moore. In 1895 Mr. Maxwell died, and Mr. Manning having retired in 1905, Mr. Moore incorporated the business into a five-million-dollar corporation, Manning, Maxwell & Moore, Incorporated, of which he is president and controlling owner. The business of this company is the manufacturing and selling of machine tools, electric cranes, boiler fittings and supplies, with headquarters in New York City, and branches in fourteen principal cities in the United States, Mexico, Japan, China and the Philippine Islands. Mr. Moore has gained considerable prominence politically, and has been repeatedly offered nominations as mayor of the old city of Brooklyn (where he made his residence for many years) and of Greater New York. He was a warm friend of William McKinley and Mark Hanna, and was one of the two messengers who delivered the official vote of the State of New York at Washington, at the time of McKinley's first election. For nine years Mr. Moore has been president of the American Protective Tariff League.

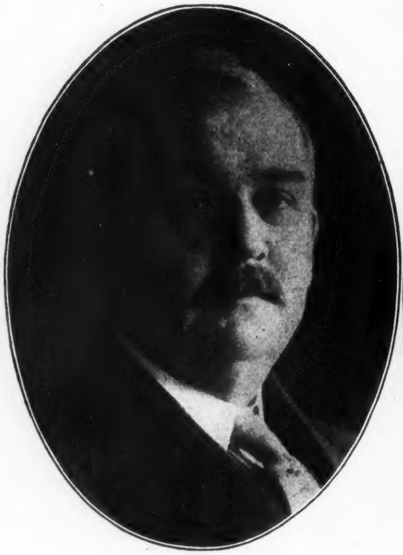
Col. H. G. Prout, executive member, and vice-president of the Union Switch & Signal Co., was born in Fairfax county, Va. His early work was hard and when in 1863, he enlisted in a Massachusetts regiment, his constitution was well prepared to withstand the rigors of military service. He was mustered out in 1865 and entered the University of Michigan in 1867 which he left in the middle of his senior year. He was later given his degree as a civil engineer after several years of active life. He served as an engineer in the War Department of the United States and then went to Africa and there, during his stay of about five years, was advanced to the grade of colonel

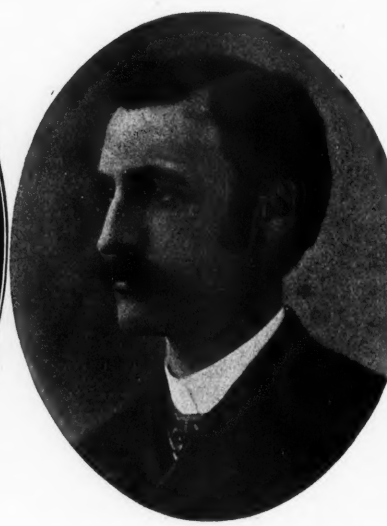


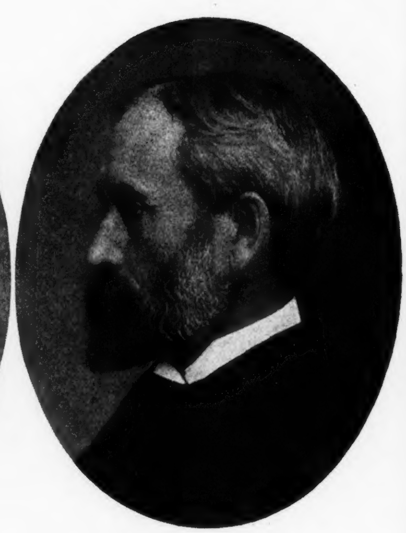
Oliver Crosby.

A. B. Johnson.

W. B. Leach.


A. M. Kittredge.


E. B. Leigh.


H. G. Prout.

in the General Staff of Khedive of Egypt. After his return to America he was, for a little over a year, signal engineer to a company out of which grew the Union Switch & Signal Co. He engaged for a few years in business in the city of New York and in 1887 became editor of the Railroad Gazette, which position he held for sixteen years. He left the Gazette in 1903 to become vice-president and general manager of the Union Switch & Signal Co., which position he has held to date. In the words of one of his assistants "Whatever Colonel Prout has done since 1903 is well known history of the Union Switch & Signal Co."

A. M. Kittredge, executive member, was born in Dayton, Ohio, in 1854. He became an apprentice in the sheet iron business at the age of 16, became foreman immediately upon the expiration of his apprenticeship and was later made superintendent of a large factory which position he held until 1877. After this until 1884 he covered the territory west of the Ohio and east of the Mississippi as a salesman for the H. W. Merriam Shoe Co. In 1884 he accepted a position with the Barney & Smith Car Co., became assistant superintendent of the plant in 1886, superintendent in 1888, vice-president in 1900 and president in November, 1908. During his connection with this plant the amount of business has increased its volume ten times. The Barney & Smith Car Co. now employs 3,500 men, and manufactures all classes of railroad cars from the most elaborate sleeper to the plainest freight car, in either wood or steel construction or composite construction.

Edward B. Leigh, executive member, is president and general manager of the Chicago Railway Equipment Co. He was born at Townsend, Mass., in 1853, and moved to St. Louis, where he secured his education at Washington University, in 1855. He was prominent in the grain elevator business in St. Louis in which he associated until 1882 when he became manager of the American Air Brake Co. He organized the National Hollow Brake Beam Co. of Chicago in 1888, of which he was manager until January, 1902, when he assisted in organizing the Chicago Railway Equipment Co. (which succeeded to the business of the National Hollow Brake Beam Co.) and has since been president, general manager and treasurer.

W. B. Leach, executive member, served an apprenticeship to the machinist's trade at the Old Colony railroad shops in South Boston, Mass. After working in various positions as machinist, assistant foreman, foreman, shop foreman with additional duties for a couple of years as foreman in charge of wreck train, until 1896, he was offered a position as general foreman of the N. Y. N. E. shops at Norwood, this road two years later being absorbed by the N. Y. N. H. & H. R. R. R. He continued in that capacity until 1902 when he was offered and accepted a position on the Boston & Albany R. R. as master mechanic of the Albany division with headquarters at West Springfield, Mass., remaining there until January 1, 1904, just before which time he was offered the position of general manager and treasurer of the Hunt-Spiller Manufacturing Corporation, accepting the position on Feb. 1, 1904. Under his efficient management the business of this concern has steadily increased, until now its product, then little known, is used by railroads all over the country.

John F. Dickson, executive member, is president of the Dickson Car Wheel Co., of Houston, Texas. A detailed account of Mr. Dickson's services to conservatism in railroad regulation would make a long story. In brief by making the acquaintance of all the representatives and senators in the Texas legislature, by sending them circulars, cartoons and letters he exerted a great influence and was undoubtedly instrumental during 1909 in bringing about the celebrated series of adjournments without action in successful extra sessions called by the Governor expressly for the purpose of carrying through an elaborate anti-railroad campaign of legislation.

Edward L. Adreon, executive member, was born in St. Louis in 1847 and was educated in Wyman's St. Louis University. He entered the office of city comptroller of St. Louis in 1865 and remained there twenty years, the last eight as comptroller, to which position he was twice elected. Since April, 1887, he has been vice-president and general manager of the American Air Brake Co., St. Louis, and since August, 1888, southwestern manager of the Westinghouse Air Brake Co., and the Westinghouse Traction Brake Co. He is vice-president of the Broadway Savings Trust Co., secretary and treasurer of the Westinghouse Automatic Air & Steam Coupler Co., director of Adreon & Co. and of the Chicago Railway Equipment Co.

Alba B. Johnson, executive member, was born in Pittsburg, Pa., in 1858. He secured his education in the public schools of Philadelphia, graduating from Central High School in 1876. He entered the service of the Baldwin Locomotive Works the following year, and has been continuously identified with them since then, with the exception of about two years, 1878 and 1879, spent at the Edge Moor Iron Works, of Wilmington, Del. In 1896 Mr. Johnson entered the firm of Burnham, Williams & Co., successors to Burnham, Parry, Williams & Co. On July 1, 1909, the firm was incorporated as the Baldwin Locomotive Works, when Mr. Johnson became vice-president and treasurer. He is a director of the Standard Steel Works Co., of the Fourth

Street National Bank, and of the Pennsylvania Company for Insurance on Lives and Granting Annuities. He is also a trustee of Jefferson Medical College and Hospital.

Joel S. Coffin, executive member, was born in St. Clair county, Mich., in 1861. His business career began at a very early age and his first occupation was in the lumber woods of northern Michigan, where he learned the trade of blacksmith. In 1876 he entered the shops of the Chicago & West Michigan R. R. at Muskegon, Mich., as a machinist's apprentice. After completing his apprenticeship in 1880 he began firing a locomotive on the same road and in a short time thereafter was promoted to the position of engineer. Beginning in 1884 he ran an engine on the Wisconsin Central Ry. and in 1889 was promoted to the position of general road foreman of engines. In 1892 he entered the service of the mechanical department of the Galena-Signal Oil Co. and in 1897 was made manager of that department. In 1907 Mr. Coffin was elected vice-president of the Galena-Signal Oil Co., and in January, 1909, resigned that position to accept the vice-presidency of the American Brake Shoe & Foundry Co., which position he now holds. In addition to Mr. Coffin's connection with the American Brake Shoe & Foundry Co. he is president of the Venango Manufacturing Co. of Franklin, Pa., and the Franklin Railway Supply Co. of New York.

Seasoning and Preservation Treatment of Cross-Ties*

It is not my intention to bring to your consideration an expedient for the preservation of our forests, nor is it my intention to attempt to cover the broadening field of chemical preservation of timber; my object is simply to present to you a few of the questions now being asked by interested railroad men pertaining to the seasoning and preservative treatment of wooden cross-ties, and to answer them as well as I can from the standpoint of some practical experience. It is hoped that what little is contained in this paper may be the means of eliciting from others new and better ideas on this very interesting and important subject.

Probably there is no other interest in this country today which can compare with the railroad as a timber consumer, and certainly there is none which is more directly and vitally concerned in seeing that a constant supply of timber is assured in the future.

In 1908 the steam roads purchased, according to a Forest Service statement, 10,565,925 treated ties, and in addition they treated at their own plants 12,590,643, making a total of 23,156,568 for the year, or 21.8 per cent of the total number purchased.

Today there are upwards of seventy timber-treating plants in this country. Many of them are either owned or their output contracted for by the railroads, and are engaged almost entirely in treating cross-ties.

2—KINDS AND QUANTITY OF WOOD USED.

It is estimated that the requirements for renewals alone amount to more than one hundred million ties annually, nearly one-half of which are of oak, about one-quarter of pine, and the balance of fir, cedar, chestnut, cypress, tamarack, etc.

Up to within a few years ago nearly all of the ties used by the railroads were made of white oak and longleaf pine. They were obtained in large quantities, at a low cost, and combined strength with great durability. These woods are each year becoming more scarce, are rapidly advancing in cost, and, as a result, the railroads are turning to the so-called inferior woods, such as the red and black oaks, lodgepole, shortleaf and other pines, and the maples, gum, hemlock, beech, etc., for their supplies. The latter are not nearly so durable as the former, especially when brought in contact with the ground, and therefore require some kind of treatment to prevent decay.

*From a paper by F. J. Angler presented before New York Railroad Club.

It has been proved beyond all doubt that these inferior woods can be chemically treated so that their life will be prolonged several years, making them last as long, or even longer than the best white oak untreated.

3—PRESERVATIVES USED.

More than 56,000,000 gallons of creosote and nearly 19,500,000 pounds of zinc chloride were used in preserving timber in the United States in 1908. Small quantities of crude oil, corrosive sublimate, and other chemicals were also used. Sixty-nine per cent of the creosote used was imported, and but thirty-one per cent obtained from domestic sources. Nearly three-fourths of the imported creosote came from England and Germany; some was obtained in Nova Scotia, and some in Scotland and Holland. The domestic creosote was obtained chiefly in New York, Philadelphia and other large cities. The zinc chloride was all obtained from domestic sources, according to the reports. Most of it was produced by a few large chemical companies.

4—SEASONING.

For the best results, cross-ties, as well as other timber, should be seasoned before applying a preservative. This can be done naturally or artificially, and no doubt the former way is much to be preferred; in fact, with some methods of treatment it is absolutely necessary.

Woods vary considerably in their seasoning properties. The coniferous woods check and split slightly as compared to some of the broad-leaved woods. For this reason they may be piled in more open piles and seasoned more rapidly. Such woods as ash, elm, hickory and beech seem to have a great tendency to check in rapid seasoning, and these ties should be piled closer together, and the seasoning retarded to some extent. A good plan is to place "S" irons in the ends of these ties as fast as they give evidence of splitting.

The time of the year in which ties are cut is said to have considerable influence in proper seasoning. Ties cut during the fall and winter are preferred to those cut during the summer, and some roads specify that ties will be accepted only when cut between October and the following April.

(*b*) INFLUENCE OF PILE FORM ON RATE OF SEASONING.

Ties should be piled at the treating plant in such a manner as to expose the greatest surface to the free circulation of the air, as the object is to dry the wood, so that it may be in proper condition to take the treatment. Ties piled in open cribs season much more rapidly than when piled in solid cribs.

A study of these results of a test shows that in three weeks the loss in the open crib pile was more than twice as much as in the solid pile, or nearly as much as the solid pile lost in two months. At the end of three months there was a difference of more than 6 per cent in favor of the open pile.

It has been found that ties piled 7x1 or 8x1 season practically as quickly as those piled 7x2, and, in addition, there is the advantage of economy in space, and, furthermore, every other tier being on a slant, water is shed to some extent.

Ties that have a great tendency to check and split should not only be piled close together, but should have the ends partially protected from the direct rays of the sun, by piling in such a way that the cross tie above laps over the ends of the ones underneath.

5—PRESERVATIVE TREATMENT.

(*a*) PROCESSES.

There are a number of different processes, or methods, of treating timber. Nearly all of them employ heavy oil of coal tar (commonly called "creosote") or chloride of zinc, either separately or in combination. Among the more prominent processes used in this country may be mentioned the following:

"Burnett," using zinc chloride.
"Bethell," using creosote.
"Rueping," using creosote.
"Lowry," using creosote.
"Allardyce," using zinc chloride and creosote.
"Card," using zinc chloride and creosote.
"Non-Pressure" or "Open Tank."

(*b*) ABSORPTIVE POWER OF TIMBER.

Some woods naturally absorb the preservative readily, while others are more or less refractory. Among the easily treated woods may be classified certain pines, soft maple, elm and birch.

The gums, poplar, sycamore, etc., require a somewhat longer time to get a good penetration, while the oaks, hickory, beech, hemlock and tamarack are usually more or less difficult to treat, although when thoroughly seasoned, and with some processes a very good treatment can be obtained.

For the best results, each kind of wood should be treated by itself. This is not always practicable, in which case they may be classified into two or more classes. On the Burlington Road, at the present time, three classes are used. Class "A" includes all wood absorbing less than 22 per cent in volume; class "B" from 23 per cent to 30 per cent, and class "C" more than 30 per cent. Each class requires a different strength of solution, when zinc chloride or a combination of zinc chloride and creosote is used. This is necessary in order to leave a certain quantity of the preservatives in the wood after the treatment is completed.

In treating sixteen different kinds of wood in one cylinder at the same time, cypress absorbed the most and hickory the least.

Another test would doubtless give slightly different results, but from numerous tests made, the one presented here gives a very good illustration of the relative ease in which these woods absorb the solution under exactly the same conditions.

(*c*) STEAMED VERSUS NON-STEAMED TIES.

When ties are thoroughly air seasoned, steaming is generally unnecessary, and in fact may be detrimental. When green, containing considerable sap or pitch, or when completely water-soaked from lying in the water a long time, it is often necessary to resort to artificial seasoning to get a good absorption of the preservative. This is usually obtained by subjecting the timber to a steaming process, at temperatures varying from 10 to 20 pounds of steam pressure for ties or smaller timber, to 30 or more pounds for piling and large dimension material. The duration of steaming may extend over a period of from two to five or more hours, depending entirely upon the condition of the wood.

The claim made for the steaming operation is that certain elements contained in the wood are more or less liquified and are expelled by the heat generated in the cells, thereby increasing the premeability of the cell walls.

The steaming of pine resulted in a gain of 4.8 per cent after the steaming, of which 1.73 per cent was lost after the vacuum, or in other words after the steaming and vacuum operation, the timber had increased in weight 3.07 per cent and this increase consisted of moisture. In the case of the green timber, the increase after steaming was .58 per cent, while after the vacuum there was a loss of 1.19 per cent.

The Burlington test, and many others along the same line, shows that when dry timber is steamed the weight of the wood is really increased by moisture and with green timber there is a slight loss after steaming and vacuum. There is perhaps no question but that a preliminary treatment with steam does render green or unseasoned wood more permeable for a water solution treatment.

Thoroughly seasoned lodgepole pine treated without steam gained 80 per cent in weight, while with steam the gain was but 76 per cent. Thoroughly seasoned Douglas fir treated without steam gained 42 per cent in weight, while the gain with steam was but 39 per cent. The reverse is true with unseasoned timber, as the results of a test show.

COST OF TREATMENT AND RETURNS ON INVESTMENT.

A plant consisting of three treating cylinders, each six feet in diameter and 132 feet long, will have a capacity of about a million and one-half ties annually. Estimated cost of plant, $175,000. The life of such a plant is estimated to be at least fifteen years.

To arrive at the cost of treating ties, the following items are considered:

First—Interest. $175,000 invested at 5 per cent compound interest for fifteen years represents an annual charge of $12,587.

Second—Depreciation. Estimating the life of the plant at fifteen years, we will charge off 6 2-3 per cent or $11,666 annually.

Third—Insurance. The stock of ties, as well as the buildings should be insured and a reasonable estimate may place the annual premium at $5,000.

Fourth—Freight on Ties to Plant. It would not be right to charge all freight on ties to the treatment, but it may be reasonable to assume that every car of ties for treatment is hauled on an average of 100 miles, and we can base the freight haul on a rate of ½ cent per ton per mile. Also estimate that cars will hold an average of 390 ties each, and that the ties will average 135 pounds in weight. Thus, a million and a half ties will require 3,846 cars to haul them to the plant, and these ties weigh 101,250 tons. This represents an annual expediture of $50,625.

Fifth—Switching. To switch 3,846 cars of ties, plus approximately 500 more containing preservatives, fuel, etc., or say a total of 4,346, in and out of plant at fifty cents per car, will cost $2,173.

Sixth—Per diem on Cars. It is not always possible to unload ties the same day received; in fact, it often happens that they are delayed a week or more from one cause or another, in which case we are called upon to pay a per diem charge of 25 cents or 50 cents. For our present purpose it may be reasonable to estimate $1 per car, or an annual cost of $3,846.

Seventh—Operating Plant. This will include all labor and material other than itemized above, estimated $300,000.

SUMMARY OF ABOVE.

	Total Cost per Yr.	Cost per Tie.
First—Interest	$ 12,587.00	$0.0084
Second—Depreciation	11,666.00	.0078
Third—Insurance	5,000.00	.0033
Fourth—Freight on Ties	50,625.00	.0337
Fifth—Switching	2,173.00	.0014
Sixth—Per Diem on Cars	3,846.00	.0026
Seventh—Operating Plant	300,000.00	.2000
Total	$385,897.00	$0.2572

We do not know just what life these ties will give, but it may be fair to assume twelve years for treated ties, and six years for untreated ties, or in other words, treating will double their life. For our purpose of comparison we will not consider tie plates in either case.

UNTREATED TIES.

(LIFE ASSUMED AS 6 YEARS)

First cost of tie (estimated)	$0.500	
Insurance, interest, freight, etc. (as per statement ("A")	.0435	
Cost of putting in track	.150	
Cost of tie in track		$0.693
5 per cent compound interest on investment for six years	0.2320	
Second renewal end of six years	0.6935	
5 per cent compound interest on 1st investment for six years and 5 per cent on 2d investment for six years	0,5503	
		$1.4758
Total cost of tie for period of 12 years		$2.1693
Average cost per tie per year		0.1808

TREATED TIES.

(LIFE ASSUMED AS 12 YEARS)

First cost of tie (estimated)	$0.7572	
Cost of putting in track	0.15	
Cost of tie in track		$0.9072
5 per cent on $0.9072 for 12 years		.7220
Total cost of tie for 12 years		$1.6292

Average cost per tie per year	.1357
Saving per tie per year	$0.0451

Taking capacity of plant at 1,500,000 ties, this would show an annual saving of $67,650, which is nearly 39 per cent on the original investment of $175,000.

(STATEMENT "A")

UNTREATED TIES.

	Total.	Per Tie.
Insurance (assumed to be the same as with treated ties)	$ 5,000.00	$0.0033
Freight (assumed to be one-half as much as with treated ties)	25,312.50	0.0169
Switching 3,846 cars of ties in and out of storage yards at 50 cents per car	1,923.00	0.0012
Per diem on cars (assumed to be the same as with treated ties)	3,846.00	0.0026
Handling ties in storage yard (unloading 1,500,000 ties from cars to ground at $0.007 each, and loading from ground to cars at same rate)	21,000.00	0.0070
Interest on 750,000 ties, or 5 per cent on $375,000 (assuming that one-half the ties are in the storage yard constantly)	18,750.00	0.0125
	$75,831.50	$0.04335

Railway Signaling*

Railway Signaling consists of interlocking, block and train order signaling. The first provides for the safe passage of trains over routes which may conflict with other routes; the second provides a space interval between trains on the same track; and the third conveys to trains instructions to stop or slow down for orders.

Interlocking may be either mechanical or power operated—block signaling may be manuel, controlled manual or automatic.

Mechanical interlockings vary in the type of locking employed, whether horizontal or vertical, latch or lever type, and in the detailed design of the apparatus.

The principal types of power interlocking are the hydraulic hydro-pneumatic, pneumatic, electro-pneumatic and electric—all but the last two, however, being obsolete or very little used at this date.

Power interlockings are used (first) where traffic conditions require very rapid operations of signals and switches; (second) where switches are located at such a distance from the tower as to preclude their operations by mechanical connections; and (third) where the plant is of such size as to make its operation by power more economical than by mechanical means both in the space occupied by the machine and its appurtenances and in the cost of labor for operation and maintenance.

Manual block signaling is the simplest system and consists in spacing trains by the display of manually operated signals based on information conveyed by telegraph, telephone or bell code between two stations. The controlled manual systems which embrace the various forms of lock and block and the electric train staff are improvements over the simple manual system in that the co-operation of two persons, one at each end of the block is required before a train can be admitted thereto. Certain controlled manual systems also depend on the condition of the tracks. The electric train staff and its double, the electric tablet system, require in addition to the co-operation of two signalmen that the engineman or conductor of a train shall, before being admitted into any block, obtain a token in the form of a staff, ticket or tablet, which token gives him a tangible right to occupy that block and which remains in his possession all the time he occupies it.

In automatic block signaling the signals are controlled entirely by the condition of the tracks, no operators at all being required. The signals used are the electric disc, the clock-work banner, the electro-pneumatic, the electric motor and the electro-gas semaphores. Any of these may be operated by direct or alternating track-circuits, depending on local conditions.

Having now outlined the general idea of Railway Signaling, some points concerning its history may be interesting.

When the first public railways were built in England early in the nineteenth century, their managers very soon discovered the necessity of some form of signaling, or in other words, some way of conveying information and instruction to trains.

The first signals used were of many shapes and colors, depending on the particular ideas of different engineers.

Each road assigned certain meanings to certain signals, irrespective of what they might mean on another road.

Confusion naturally resulted, and some accidents occurred, but no real improvement was made until Mr. C. H. Gregory adapted semaphore to railway uses in the year 1840, and it has remained ever since, growing in popularity every year till it stands today the most perfect signal so far devised, because the most natural. Signals of many designs have been invented since then but none have ever approached it in popularity.

Somewhere between 1840 and 1845, the first attempts were made to operate a number of switches and signals from some central points by means of levers and pipes or wire connections. In the first installation of this nature, no provisions were made to mechanically check the operation of the switches and signals, and in consequence, switches were occasionally thrown under trains, and signals sometimes cleared when switches were improperly set. To remedy the first defect, the detector bar was designed, consisting as now of a long bar extending alongside the track, which was raised and lowered each time the switch to which it was connected was operated.

If a train occupied the track the bar could not be raised as it would strike against the flange of the wheels. It was found, however, that when the bar was connected to the same lever which operated the switch, the latter could be moved to a dangerous amount before the bar could strike against the wheel flanges. To overcome this defect the detector bar was operated by a separate lever which was also used to lock-switch points, and as these extra precautions were only considered necessary on facing-point switches the device became known as the "facing-point lock," which name it still bears.

It is an interesting fact that the first idea of operating a number of switches and signals from one central point was done mainly for the reason of economy, or, in other words, to save labor of switchmen.

In this country the first interlocking plants were installed largely as a measure of safety and in many cases where grade crossings were interlocked, switches which before the interlocking was installed had been located close to the crossing were moved away so as to bring them outside of the interlocking limits with the idea of reducing the size of the interlocking machine, and consequently, the first cost of the plant itself. This practice is occasionally followed today.

In the first plants installed in England, no attempts were made to interlock the levers in any way until about the year 1847, when owing to several accidents having been caused by signalmen operating the wrong lever, Mr. Stevens devised a scheme in which the signalman worked the switches with ordinary levers and the signals by means of stirrups placed immediately adjoining the switch levers to which the signals applied; thus, when the signalman moved the switch with his hand he moved a signal with his foot and this arrangement to a certain extent counteracted the danger of concentration. There was, however, no mechanical obstacle to the signalman moving a stirrup before he moved a switch nor was there any mechanical connection between different levers or different stirrups. The first real mechanical interlocking, as we now understand it, appears to have been devised by Mr. Saxby about 1856 and improved by Mr. Chambers and Mr. Saxby in 1860.

*Paper presented before Richmond Railway Club by I. H. Patenall, U. S. & S. Co.

The actual operation of the block system dates from December, 1839, when the Great Western Railway of England, began telegraphing the arrival and departure of its trains from stations to station for a short distance, near London. This was at the suggestion of Messrs. Cooke and Wheatstone, who, in 1841, introduced separate instruments for each direction of traffic, showing whether the sections were clear or blocked. They also added telegraph bells.

The first well-authenticated published suggestion of the block systems were contained in a pamphlet printed in 1842, entitled "Telegraphic Railways," by Mr. (afterwards Sir) W. F. Cooke, an English engineer. He laid down the following principles:

"Every point of a line is a dangerous point, which ought to be covered by signals. The whole distance, consequently, ought to be divided into sections, and at the end as well as the beginning of them, there ought to be a signal, by means of which the entrance to the section is opened to each train when we are sure that it is free. As these sections are too long to be worked by a traction rod they ought to be worked by electricity. At the end of each section of from two to two and a half miles, a line-keeper is stationed in a hut, with a turning disk, or a semaphore. In each hut there ought to be two telegraphs with magnetic needles, the one on the right hand being in communication with that on the left of the neighboring hut. The needle telegraph can only give two signals: 'line clear' or 'line blocked.'"

It will be noticed that this embodies all the leading features of the block systems of today. The constantly increasing volume of business on railroads soon made it necessary to improve the means for securing safety in operation, and in 1851, Mr. C. V. Walker, of the South Eastern Railway of England, devised the method of signaling by electric bells, the signals being by sound only, no needle instrument being used. In 1854 the London & North Western Railway introduced separate instruments for each track with three positions of the needle, and later used the bell code in connection therewith.

The Sykes system of block signaling was invented in 1875. In this method the signals at a block station are controlled by the signalman at the station in advance, by means of electrically-operated locks, the locking apparatus at the two stations being connected by an electric circuit. This effected a decided check against mistakes or carelessness, for while each signalman operated his own signals, he could not operate them until they had been unlocked by the signalman in advance, on request of the first signalman.

Although automatic signaling does not seem to have been tried in England prior to its adoption here, yet a patent was granted in that country in 1862, to a Mr. John Imray, which covered the following:

First: A Rotating banner signal operated by clock-work and controlled electrically in an almost identical manner to our own.

Second: Means for operating such a signal either by hand switches or by track treadles or instruments operated by the wheels of passing trains; and

Third: Signal repeaters, annunciators and track indicators, all worked automatically.

The electric train staff system of today is a gradual development from a simple principle for the operation of railroads which was recognized in England as early as 1840—namely, that to safely pass over a given section of single track, every train should have in its possession a tangible right to do so in the form of some specific article of which there is only one obtainable. The first train staff was a metal bar about two feet long, which had cast or engraved on it the name of the two stations between which it alone gave authority for any train to proceed. Unless trains moved alternately in opposite directions the staff had to be returned over the section by a special engine or in some cases by road.

To partially overcome this difficulty the staff and ticket system was devised, in which device the original staff became a key that would unlock a box at either end of the section and permit tickets to be taken therefrom. If it was desired to say forward three trains from one station to another before one should proceed in the opposite direction, the ticket box was unlocked by the staff and a ticket given to the first and second trains, the third train receiving the staff.

Since an engineer or guard of any train when receiving a ticket was required to see the staff as well, this system, made head-on collisions impossible. In 1878, Mr. Edward Tyer introduced his electric tablet apparatus which consisted of two instruments, one at each end of a section, each instrument containing a certain number of tablets, any one of which constituted the right of a train to pass over that section. The two instruments were electrically connected and synchronized so that the removal of a tablet from either instrument absolutely prevented any other being taken out.

In 1889, Mr. Webb, the Chief Mechanical Engineer, and Mr. Thompson, the Signal Superintendent of the London & North Western Railway, invented the Webb & Thompson Electrical Train Staff, in which staffs were substituted for the tablets in the Typer system and a permissive feature added whereby several trains could follow each other into a block section if desired, in a manner similar to that employed in the non-electrical staff and ticket system.

In the United States the first signal system of which we have any record was erected on the New Castle & Frenchtown Railroad in the year 1832. This system included five signals, each of which comprised a post with a gallows arm on top equipped with a rope and pulley by means of which either a white or black ball was hoisted to the end of the gallows. The use of these signals, however, appears to have been more to convey information rapidly between the stations on the line than to control train movements or convey information to trains.

It may be said therefore, that signaling was practically unknown in this country till the seventies. Certain railroads built a few signals of their own devising to meet special contingencies but interlocking was practically unknown till 18774, when the Pennsylvania Railroad contracted for the installation of an English Saxby and Farmer plant at Trenton or East Newark, New Jersey (the records are a little indefinite on this point). This machine was imported from England and installed by English mechanics who came over with it.

A year later a number of Toucey & Buchanan machines were installed on the New York Central, and in 1876 several of these were also installed on the Pennsylvania Railroad.

They differed from the Saxby & Farmer machines in that they did not have preliminary locking and were replaced later with Saxby & Farmer machines.

Although inventors had dreamt of interlocking machines operating by power for a number of year, yet apparently the first practical machine of this nature to be installed in this country was at the west leg of the Mantua Y, Philadelphia, in 1876. This was installed under the patents of Prall & Burr. While the apparatus was crude in many ways, still it gave reasonably good results, but the inventors in some way lost interest, and did not do anything further with their invention.

At a later date, Mr. Westinghouse became interested in power interlockings and took out several patents on both hydraulic and pneumatic systems. These patents were used by the Union Switch & Signal Company, which was incorporated in 1882, being a combination of the Toucey & Buchanan and Union Electric Signal Companies.

The first Union Switch & Signal Company's power interlocking, a hydraulic plant, was installed at Wellington, O., in 1882, and in 1883-4 the first hydro-pneumatic plant was put in service at Bound Brook, N. J., on the Central Railroad of New Jersey. From that time onward the electro-pneumatic system has been developed rapidly to its present state.

While it was considered safe to operate signals electro-pneumatically as early as 1883, yet up to 1891 all switches were operated by valves in the interlocking machines admitting and releasing air to and from a normal and reverse pipe filled with water in summer and a compound in winter to prevent freezing, which operated an auxiliary valve near the switch.

In that year, the Union Switch & Signal Company devised the present electro-pneumatic switch valve, the first being installed on the drawbridge interlocking on the Chicago & Northern Pacific at Chicago. The results were so satisfactory that practically all plants from then on were so equipped.

In 1888 Mr. J. D. Taylor, at that time a telegraph operator, in a small town in Ohio, became interested in electrical devices to be used in train dispatching. Having obtained patents on this device, he in company with some other gentlemen attempted to interest the officials of the B. & O. South Western in it.

Mr. I. G. Rawn, at that time General Manager of the road, suggested to Mr. Taylor that some principles embodied in the device might be used in railway signaling, and though the latter at that time had practically no experience in signaling matters, he agreed to attempt to devise an electric interlocking system. In 1889 Mr. Taylor went to Chicago, where he built four electric semaphores and a machine for operating them, which he exhibited in the Exposition Building on the Chicago Lake Front, where they were inspected by a number of railroad officials in the winter of 1889-90. In the model plant exhibited by Mr. Taylor, no attempt was made to operate derails or switches, but merely electric semaphore signals.

Mr. Taylor went to Indianapolis, where he visited a mechanical interlocking plant and carefully studied the different parts of the apparatus. Having done so, he returned to Chillicothe and constructed the first Taylor electric interlocking in the Baltimore & Ohio South Western shops, which was installed at East Norwood, Ohio, on the crossing of the Baltimore & Ohio South Western and the C. L. & N. in 1890-91. This was about a year later than the first Ramsey and Weir electric interlocking, which was erected at College Hill, Ohio, on the C. H. & D. in 1890, a second plant having been installed at the Grand Central Depot in Cincinnati in 1891.

In the first Taylor interlocking at East Norwood, the switch movements were mounted on platforms raised about three feet above the track level to keep the electrical parts from getting wet and the insulated wires between the machines and the movements were buried in the ground without any attempt being made to protect them from injury. Numerous troubles were experienced with this first plant, grounds and crosses developed in the wires, which had to be renewed and placed in wooden trunking, and the storage battery played out at the end of six months. All these troubles were, however, finally overcome by Mr. Taylor, and the plant worked satisfactorily until about 1904, when it was removed and replaced by a later interlocking. In 1900 the Taylor Signal Company was reorganized and was later consolidated with the General Railway Signal Company.

In 1866 or 1867, Thomas S. Hall of Hartford, Conn., installed some automatic electric signals on the New York, New Haven & Hartford Railroad. These signals were operated by the depression of track instruments or treadles under the wheels of moving trains, thereby controlling the electrical circuits which operated the signals. An improved type of this apparatus was also installed by Mr. Hall on the New York & Harlem and on the Eastern Railroad in 1872 and 1873.

To Franklin L. Pope and William Robinson is due the credit of devising a practical track circuit, the first one of which was installed in 1871 and 1872, on the Boston & Lowell Railroad. Mr. Pope demonstrated the practicability of operating a track circuit submerged in water at the Centennial Exposition in 1876 in Philadelphia. The names of David Rousseau and Dr. Whyte are also connected with early experiments in automatic blocking.

In 1879 the track circuit was installed in combination with the clock-work disc signal designed by Gassett & Fisher on ten miles of the Fitchburg Railroad, and two years later a similar outfit was installed by the Pennsylvania Railroad between Altoona and Gallitzin. Meanwhile the electro-pneumatic signal was being improved and adapted to automatic purposes, the first electro-pneumatic automatic block signal having been applied to the Fitchburg Railroad in 1883, and to the West Shore and the Pennsylvania Railroad in 1884.

The semaphore signal actuated by purely electrical means had not been seriously considered for automatic block signaling until the year 1897, although electric semaphores had been built by Ramsey and Weir, Taylor, Lattig and others. These signals, however, usually consisted of an electrical mechanism which could be attached to the outside of an ordinary semaphore signal. In 1897 Mr. J. P. Coleman devised the first really successful electric semaphore to operate on primary batteries in which the mechanism and the connections between it and the semaphore arm were all enclosed inside of the post. The two first signals of this type manufactured were installed that year within a few days of each other, one at the Michigan Central Depot in Detroit and the other at the Broad Street Station, Philadelphia. A little later Mr. V. K. Spicer conceived the idea of a signal mechanism employing a slot arm driven from a motor by a bicycle chain from which mechanism the present style "B" mechanism of the U. S. & S. Co. developed in 1898. The first one of these signals was installed in that same year and today there are nearly 27,000 of them in successful operation. The Coleman Signal (Style "C") was successful as far as it went, but in view of the fact that the style "B" was designed to operate any number of slot-arms from one motor which the Coleman signal style "C" was incapable of doing, it eventually gave place to the former. Other inventors followed with electric semaphores and within a few years there were several different types on the market. The Hall Signal Company in the year 1902 placed their electro-gas signal in successful operation on several railroads and for quite some time there was a large demand for it.

The new development of the art was the use of alternating current for track-circuiting purposes, practically on roads employing electric propulsion. The idea was conceived by Mr. Struble in the year 1901, and the first installation under service conditions was that on the North Shore Railroad in California in 1902, to be followed by the Interborough Rapid Transit Company in New York in 1903-5. The present systems are somewhat costly to install, and although this has been considerably reduced since the first installation, still there is room for further reduction if the system is ever to be adopted largely by the cheaper class of electrically operated railroads.

What Forests Do

Our industries which subsist wholly or mainly upon wood pay the wages of more than 1,500,000 men and women.

Forests not only grow timber, but they hold the soil and they conserve the streams. They abate the wind and give protection from excessive heat or cold. Woodlands make for the fiber, health, and happiness of each citizen and of the nation.

The fish which live in forest waters furnish each year $21,000,000 worth of food, and not less than half as much is furnished by the game which could not exist without the forest.

WHAT WE HAVE.

Our forests now cover 550,000,000 acres, or about one-fourth of the United States. The original forests covered not less than 850,000,000 acres.

Forests publicly owned contain one-fifth of all timber standing. Forests privately owned contain at least four-fifths of the standing timber. The timber privately owned is not only four times that publicly owned, but it is generally more valuable.

Forestry is now practiced on 70 per cent of the forests publicly owned and on less than 1 per cent of the forests privately owned, or on only 18 per cent of the total area of forests.

WHAT IS PRODUCED.

The yearly growth of wood in our forests does not average more than 12 cubic feet per acre. This gives a total yearly growth of less than 7,000,000,000 cubic feet.

Nearly all our native commercial trees grow much faster than those of Europe. We already grow post timber in twenty to thirty years, mine timber in twenty-five to thirty-five years, tie timber in thirty-five to forty years, and saw timber in thirty to seventy-five years.

We have 200,000,000 acres of mature forests, in which yearly growth is balanced by decay; 250,000,000 acres partly cut over or burned over, but restocking naturally with enough young growth to produce a merchantable crop; and 100,000,000 acres cut over and burned over, upon which young growth is either wholly lacking or too scanty to make merchantable timber.

WHAT IS USED.

We take from our forests yearly, including waste in logging and in manufacture, 20,000,000,000 cubic feet of wood.

We use in a normal year 90,000.000 cords of firewood, 40,000,000,000 board feet of lumber, 118,000,000 hewn ties, 1,500,000,000 staves,, over 133,000,000 sets of heading, nearly 500,000,000 barrel hoops, 3,000,000 cords of native pulp wood, 165,000,000 cubic feet of round mine timbers, and 1,250,000 cords of wood for distillation.

WHAT IS WASTED.

Forest fires burn over millions of acres and destroy billions of feet of timber annually. The young growth destroyed by fire is worth far more than the merchantable timber burned.

One-fourth of the standing timber is left or otherwise lost in logging. The boxing of longleaf pine for turpentine has destroyed one-fifth of the forests worked. The loss in the mill is from one-third to two-thirds of the timber sawed. The loss in the mill product through seasoning and fitting for use is from one-seventh to one-fourth. Great damage is done by insects to forests and forest products. An average of only 320 feet of lumber is used for each 1,000 feet which stood in the forest.

WHERE WE STAND.

We take from our forests each year, not counting the loss by fire, three times their yearly growth. We take 36 cubic feet per acre for each 12 cubic feet grown; we take 230 cubic feet per capita, while Germany uses 37 cubic feet and France 25 cubic feet.

We invite by overtaxation the misuse of our forests. We should plant, to protect farms from wind and to make stripped or treeless lands productive, an area larger than that of Pennsylvania, Ohio, and West Virginia combined. But so far, lands successfully planted to trees make a total area smaller than Rhode Island. And year by year, through careless cutting and fires, we lower the capacity of existing forests to produce their like again, or totally destroy them.

The condition of the world supply of timber makes us already dependent upon what we produce. We send out of our country one and one-half times as much timber as we bring in. Except for finishing woods, relatively insignificant in quantity, we must grow our own supply or go without.

WHAT SHOULD BE DONE.

We should stop forest fires. By careful logging we should both reduce waste and leave cut-over lands productive. We should make the timber logged go further by preservative treatment and by avoiding needless loss in the woods, the mill, the factory, and in use. We should plant up those lands now treeless which will be most useful under forest. We should so adjust taxation that cut-over lands can be held for a second crop. We should recognize that it costs to grow timber as well as to log and saw it.

We should continue and perfect, by state and nation, the preservation by use of forests already publicly owned; and we should extend it to other mountain forests more valuable for the permanent benefit of the many than for the temporary profit of a few.

For each million acres of forest in public ownership over 4,000,000 are privately owned. The conservation of public forests is the smaller task before the nation and the states. The larger task is to induce private forest owners, which means 3,000,00 men, to take care of what they have, and to teach wood users, which means everyone, how not to waste.

If these things are done, they will conserve our streams as well as our forests. If they are not done, the usefulness of our streams will decrease no less than the usefulness of our forests.

WHERE WE MIGHT STAND.

By reasonable thrift we can produce a constant timber supply beyond our present need, and with it conserve the usefulness of our streams for irrigation, water supply, navigation, and power.

Under right management our forests will yield over four times as much as now. We can reduce waste in the woods and in the mill at least one-third, with present as well as future profit. We can perpetuate the naval-stores industry. Preservative treatment will reduce by one-fifth the quantity of timber used in the water or in the ground. We can practically stop forest fires at a total yearly cost of one-fifth the value of the standing timber burned each year.

We shall suffer for timber to meet our needs until our forests have had time to grow again. But if we act vigorously and at once we shall escape permanent timber scarcity.

Requisition For Piling

A requisition has been in the United States for over $70,000 worth of piling to be purchased on competitive bid. About half of this amount is for the Central Division and the remainder for stock for the Quartermaster's Department. The number and length of piles required are as follows: 650, 35 feet long; 700, 40 feet long; 700, 45 feet long; 1,400, 50 feet long; 400, 55 feet long; 900, 60 feet long; 400, 65 feet long; 2,100, 70 feet long; 200, 75 feet long; in all, 7,450 piles, aggregating 416,250 feet. These piles are to be untreated, of long leaf yellow pine, cypress, or Douglas fir, free from bark, rot, and unsound knots; not less than 14 nor more than 20 inches in diameter at the large end, and not less than 8 inches in diameter at the small end for piles 55 feet and under, nor 7 inches for piles over 55 feet in length; not less than 60 per cent heart at the large, nor less than 40 per cent heart at the small end.—Canal Record, January, 1910.

Government Publication Misquoted

The Department of Agriculture has recently been informed that certain of its publications dealing with eucalyptus have been misquoted by several companies interested in selling lands. For instance, Circular 97, of the Forest Service, has been misrepresented as saying that California will in a few years be the only source of hardwood supply in the United States. Such a statement has never been made in any of the Forest Service publications and is not considered a fact.

The Department experts believe that there is promise of considerable success in the cultivation of eucalyptus trees in many parts of California, but estimates of profit and of growth have been attributed to the Department which are unauthorized. There are many uncertainties connected with eucalyptus culture, the government experts say, which the investor should take into account.

In some cases statements falsely attributed to the Forest Service in advertising matter have been corrected when attention was called to the facts, but not before the misstatements had been widely circulated. Secretary Wilson says he does not intend to allow the name of his department to be used as a means of victimizing the public, and that in future any concern which attributes to the Forest Service unauthorized statements may expect the statements to be publicly disavowed.

RAILWAY ENGINEERING
AND MAINTENANCE OF WAY.
BRIDGES-BUILDINGS-CONTRACTING-SIGNALING-TRACK

Published by THE RAILWAY LIST COMPANY

WILLIAM E. MAGRAW, Pres. and Treas. WARREN EDWARDS, Manager
CHAS. S. MYERS, Vice-Pres. C. C. ZIMMERMAN, Adv. Mgr.
NORMAN F. REHM, Editor

Office of Publication: 315 Dearborn Street, Chicago
Telephone, Harrison 4948

Eastern Office: 50 Church Street, New York
Telephone, Cortlandt 5765

A Monthly Railway Journal

Devoted to the interests of railway engineering, maintenance of way, bridges and buildings.
Communications on any topic suitable to our columns are solicited.
Subscription price, $1.00 a year; to foreign countries, $1.50, free of postage. Single copies, 10 cents. Advertising rates given on application to the office, by mail or in person.
In remitting, make all checks payable to the Railway List Company.
Papers should reach subscribers by tenth of the month at the latest. Kindly notify us at once of any delay or failure to receive any issue and another copy will be very gladly sent.

Entered as Second-Class Matter April 13, 1905, at the Post Office at Chicago, Illinois, Under the Act of Congress of March 3, 1879.

Vol. VI. Chicago, February, 1910 No. 2

Maintenance of Way Photographs

The photographs of chairmen and vice-chairmen of the American Railway Engineering and Maintenance of Way Association will be published in the March issue of RAILWAY ENGINEERING for the benefit of new members and visitors to the convention next month at the Auditorium Annex, Chicago. Besides these photographs there will also be those of many representative officials, including the officers of the Maintenance of Way Association. The March issue should be of interest to those who desire a condensed album of railway officials.

At the convention it will be possible to obtain a copy of the paper, so it will not be necessary to take your personal copy to the convention. If you desire extra copies of this issue, you should notify us immediately. We have received this month numerous requests for extra copies as high as 50 copies for one official, and so it is possible the supply will be exhausted unless most orders are received before publication or March 1st.

Copies of the paper may also be had at our booth in the Coliseum, where some member of our staff will always be in attendance. The exhibits at the Coliseum will be numerous this year and, as usual, of an educational nature. You would undoubtedly be interested and, if you attend the convention, you should not fail to visit the Coliseum.

The Signal Department

In presenting the second installment of our series of articles on automatic block signal standards, which appears in this issue, we wish to congratulate the officers of the Rock Island signal department on the excellence and thoroughness of the work accomplished since the appointment of Mr. Shaver as signal engineer. He has not held the position two years, yet he has succeeded in organizing a thoroughly efficient department. Prior to his appointment, the Rock Island had not undertaken the installation of automatic block signals on a large scale, so that complete standards and a large construction and office force were not necessary.

Since the late autumn of 1908 the Rock Island has installed over 350 miles of automatic block signals, mostly on single track, and it is understood that the block system is to be rapidly extended. At the outset Mr. Shaver and his assistants were confronted with the problem of organizing the department, standardizing the details of construction and pushing the actual installation of the signals all at the same time. How well the work was done may be judged from a study of the standards illustrated elsewhere in this issue and from the amount of work accomplished.

Railroad Accidents

It may be noted in recent accident bulletins that few collisions are credited to automatic block signaling. In the bulletin of the Interstate Commerce Commission for the quarter ending September, 1909, only one collision was noted in which automatic signal did not operate perfectly. In the latter case foreign currents cleared the signal, which remained clear only a few seconds and turned to the stop position again before the engineman passed it.

Other accidents were due to failures to flag, misplaced switches, errors of block signal operators, conflicting orders by despatchers, oral messages, misinterpreted orders by enginemen, etc. The number of casualties, due to collisions, is small in comparison to the total number, yet the responsibility does not lie with the people who are killed or injured. We should for this reason consider seriously the automatic block signal in relation to railroad accidents. The damage to engines, cars and roadway is also considerably reduced wherever the automatic block signals are installed. A few paragraphs from the above-mentioned report are quoted below:

"The number of persons killed in train accidents during the months of July, August and September, 1909, as shown in reports made by the railroad companies to the Interstate Commerce Commission, under the 'accident law' of March 3, 1901, was 193, and of injured, 3,752. Accidents of other kinds, including those sustained by employees while at work and by passengers in getting on or off the cars, etc., bring the total number of casualties up to 20,093 (852 killed and 19,241 injured). Accidents to employees resulting in slight injuries, which do not prevent the employee injured from performing his accustomed service for more than three days in the aggregate during the ten days immediately following the accident, are not reported.

"The total number of collisions and derailments in the quarter now under review was 2,751 (1,288 collisions and 1,463 derailments, of which 228 collisions and 192 derailments affected passenger trains. The damage to cars, engines, and roadway by these accidents amounted to $2,316,014.

"The only favorable indication that can be discerned in the foregoing statistics (reference is to table in report) is that afforded by the fact that the totals of employees killed in train accidents and in coupling cars do not show such decided increases as do those of employees killed from other causes. These last-named items might be expected to increase, because of the general increase of traffic, and on this supposition the absence of increase in the others indicates improved conditions. Five accidents—collisions 14, 16, 24, and 1, and derailment No. 19—caused 47 deaths."

The Maintenance of Way Department.

Winter Track Maintenance

Editor Railway Engineering:—

Shim low joints and, where track is out of line, plug spike holes and respike. In heavy snows run snow plow night and day and see that switch points and guard rails are free from ice and snow. We have had no delays of any consequence. We use tie plates on soft wood ties and on curves.

Yours truly,

Illinois. Roadmaster.

Winter Track Maintenance

Editor Railway Engineering:—

Relative to my methods of track maintenance during the winter, I will say that I am located on a line neither small enough to develop anything of interest to your readers or large enough to produce anything out of the ordinary. I have twenty-five sections composed of foreman and two men on outside sections and three to five men on yard sections. Winter work is mostly routine, consisting of patroling, grubbing, shimming a little, when frost is in deep as it now is, and keeping tracks and crossings clear of what little snow falls. I have no use for snow plows and do not have to do any heavy shimming and usually have no new work or betterments to look after. We have not started to use tie plates, except a few on much-used turn-outs or sharp curves.

I have been furnished creosoted ties for next season's use and will use tie plates on all of them. We have had no instructions as to putting them on yet, but presume that the same methods will be employed as in the past, i. e., placing them under the rail at gauge and letting traffic seat them on the tie. I do not like this practice, but with no facilities for any other method will probably carry it out.

What is your idea regarding the adzing of a creosoted tie that will not fit the rail? You understand that the creosote penetrates in some instances not over one-quarter inch. Supposing a tie had to be adzed one-half inch to make it fit the rail, the timber being of some of the poorer grades not adopted to use as cross-ties, cutting, of course, through the creosoted skin or shell, to what extent would the value of the tie be lessened. This might open up a topic for discussion and would like to hear from some one with experience in that line.

Yours truly,

Ohio. Roadmaster.

Winter Track Maintenance

Editor Railway Engineering:—

With reference to method of maintaining track and difficulties that we have overcome, beg to say that our method of maintaining track during the winter months in order to maintain good riding track, is to shim under the rails to smoothen up the track where it has heaved. We do not use any tie plates on our line on account of using oak ties.

Yours truly,

Michigan. Roadmaster.

Laying Tie Plates

Editor Railway Engineering:—

I have just finished applying about one mile of the plates on curves, under new 85-pound rail layed in October and November, 1909.

My method of putting in tie plates is to use a gang of six men and one foreman. I always apply the plates on outside rail first, as this will only put one-half inch more elevation in your curve and I run all the way around the curve. I put out slow flags the proper distance with safety flags at hand. When trains approach I slow them down over the work.

I start two men with clawbars pulling spikes, having every other spike pulled before laying plates. Two men use spike mauls and gauge and two men put plates under ready for spiking, one man with ripping bar to hold up rail and the other man slipping plates under. The two men with mauls and gauge follow up, spiking every other tie with two spikes to gauge. Having done the adzing beforehand and what little adzing is to be done to make plate lay perfectly level (the foreman does this), the plate is leveled to track under traffic. If level after running plates all the way around on high rail, I then put four men back with mauls and full spike the plates, four spikes to each plate. Then I run the inside rail in same manner as outside rail. A foreman and six men should apply about 350 to 400 plates a day under favorable conditions. We use tie plates which are easy to apply, being smooth on bottom with a shoulder for outside of rail. I prefer to put on tie plates in winter, when this can be done. In winter season the climate is an advantage. The ground does not freeze more than six or eight inches deep and will not heave track to amount to anything.

Yours truly,

Indiana. Roadmaster.

Curvature

By C. P. Howard.

The purpose of this paper is to discuss the general subject of curvature as it appeals to and must be considered by the Locating Engineer. We have little exact information on which to base some of our most important conclusions; perhaps we never shall have. We cannot reduce to a formula the general peace of mind of passengers, enginemen or roadmasters, but meanwhile we must locate and build railroads, spending large sum of money, and we cannot wait until all the data shall have bee definitely determined. Necessarily, therefore, the suggestion here offered tentatively are matters more or less of judgmer and opinion, and it is hoped that a discussion may bring ot as far as possible the general opinion of members of the Associa tion on the points considered.

IMPORTANCE OF CURVATURE.

Curvature has been termed a "minor detail" of location. Nevertheless, its financial importance is considerable. Comparative speaking, it does not take much additional curvature per m with money at 4 per cent, to make a capitalized difference $50,000 in ten miles, or $500,000 in 100 miles on a road runnin 60 trains a day. If the grades are flat and trains heavy, cc ing, say $1.60 per train mile, 10 degrees of central angle a tional per mile would make the difference according to ordin methods of figuring.

WELLINGTON'S FLAT RULE TO START WITH.

The usual values for one degree of curvature, based by Wellington's method on estimates or guesses as to the effect on operating expenses, are perhaps the best figures to start with. Thus, if the probable number and size of trains and the cost per train mile for running them are known, we can readily compute a *flat rule* per degree of central angle. (Wellington, page 322; J. B. Berry, Proceedings, 1904, page 706; Webb, Economics of Railroad Construction, page 262.) Further on we shall discuss the value of such a rule and suggest certain improvements.

FIXING THE MAXIMUM DEGREE OF CURVE; IMPORTANCE

Knowing the maximum speed desired, we can readily fix a maximum degree of curve to correspond as that curve which requires a certain superelevation of outer rail, say six or seven inches. But if we are given a certain amount of traffic to take care of and wish to use the most economical curve, all things considered, the problem is not a simple one. We cannot tell whether such a maximum is the most economical or not, until

*From Bulletin No. 115 of the American Railway Engineering and Maintenance of Way Association.

we survey the line and make calculations to determine the relative cost of a higher or lower maximum.

It is an error to suppose that the character of the country will usually determine such matters. It is the writer's observation and experience that it usually does not. If anyone doubts this, let him look at some of the lines which have recently been rebuilt and note the difference between the long tangents of the new lines and the sinuosities of the old.

These questions are continually presented: Shall we build across the hollow or around it; shall we make two crossings of the stream or follow the curve of the bank; shall we tunnel the point or go around, etc. Even in flat country a cheap right-of-way may require curves, and the facility of locating in moderately flat regions is apt to be neutralized by the modern necessity of obtaining light grades. In rolling country, as in the mountains, the alternatives of cutting across or going around are always present, and cannot be determined correctly except by a knowledge of the value of the curvature and distance saved.

The writer recalls an instance of such revision on one of our mountain roads. The old line followed the windings of the gorge, while the new tunneled the points and bridged the stream. Probably twelve to fourteen degree curves were used on the old line, and six degrees on the new. An engineer of the road remarked: "We are building a six-degree line in a sixteen-degree country." Either can generally be done, or any variation between the two, but the problems will not solve themselves, and differences in cost are large.

WHEN TO USE THE MAXIMUM.

Having selected a maximum degree of curve, the next question is when to use it. Here we have no rule except an implied one which we consider wrong in principle, and against good practice. This rule is that the negative value of a degree of central angle is independent of the radius; that a light curve is no better than the maximum. But we know sharp curves are objectionable. We take this to be the unanimous opinion of the public as well as the railroad men of today. None of us will put in a maximum curve where we can get a lighter one, and what is more, we will spend money to make them light.

OBJECTIONS INCREASE WITH SPEED.

Objections to curvature increase with the speed of trains. We assume this to be a fact; which is to say, it is justifiable to spend more money per daily train to take out one degree of central angle on a fast line between New York and Chicago, than on a slow-speed coal branch in the mountains. It is difficult to prove this by mathematics. The centrifugal force increases as the square of the speed. The superelevation of rail designed to resist this force is a palliative rather than a cure, and when elevated for high-speed trains, is charged with being a prolific cause of derailment for slow trains. Moreover, on track elevated for forty-five miles an hour, trains may run at fifty or sixty, and when elevated for sixty miles, a speed of seventy or eighty miles may sometimes be attained.

For freight trains the conditions are different. Wellington says (page 268): "It is fully as difficult and dangerous to run freight trains over sharp curves at twenty-five or thirty miles per hour as passenger trains at sixty miles per hour, owing to the difference in their mechanical construction." We may, therefore, take about one-half the passenger train maximum as a corresponding maximum for freight trains, and it may be sufficiently accurate in many cases to figure only on the speed of passenger trains on the assumption that the speed of freights will be proportionately lower so as to give about the same economy and safety in operating over any given curve.

Assuming the above to be true, that more money may be spent to eliminate the sharper curves, requiring the maximum superelevation of rail and that the objections to curvature increase with the speed, the next question is how much more can we spend. Frankly, we do not know. Any estimate will be largely a surmise. The important proposition is, however, that the objections to curvature *do increase* with both the speed and the degree of curve in *some proportion*, and that the objections due to increased speed are not sufficiently compensated for by the fact that we use correspondingly lighter curves for higher speed. The flange pressure against the rail due to rotation of trucks is possibly the same for all curves at all speeds (see Wellington, page 291); while the vertical jolt or rebound, as stated above increases with the square of speed.*

But in order to eliminate some of the unknown quantities and replace with definite proportions, we have, as a preliminary, made these tentative assumptions, the Rules and Formula which follow being largely dependent on them:

(1) That the negative value of a degree of central angle increases in direct proportion with the speed of trains;

(2) That for any given speed of trains the negative value of a degree of central angle varies with the degree of curve and is twice as great on a curve requiring six inches elevation as on a curve requiring one inch elevation.

*We figure that when a train strikes an obstruction or a rough place in the track, the jolt, vertical rebound (or bounce) will be in proportion to the square of the speed. (Trautwine, pages 343-4, Ed. 1902.) If on a curve and the bump is great enough, the wheel may climb the rail, while on a tangent the tendency is to continue on in a straight line and stock to the rails. So that on curves of the same radius the danger of derailment from small obstructions or bad surface may be considered to vary, more or less, as the square of the speed.

RULES FOR DETERMINING THE NEGATIVE VALUE OF ONE DEGREE OF CENTRAL ANGLE.

The best or ideal rate of curve for any given maximum speed is assumed to be that degree which requires an elevation of one inch for the maximum speed as determined by the formula, $E=.00066\ DV^2$ (Manual, page 61). Any sharper curve is considered more or less objectionable up to (and beyond) a curve requiring six inches elevation, whose negative value we assume to be twice that of the ideal curve, with other intermediate rates of curve in the same proportion. On this assumption the ideal rate of curve, and the curve requiring six inches elevation, for different maximum speeds are as follows:

Speed.	Ideal Curve.	Six-Inch Elevation Curve.
60 miles per hour	0° 25′	2° 31′
50 miles per hour	0° 36′	3° 38′
40 miles per hour	0° 57′	5° 41′
30 miles per hour	1° 40′	10° 06′
25 miles per hour	2° 25′	14° 33′

As stated in the Manual, page 62, the elevation should nowhere exceed eight inches (and it is probably not safe for the speed to exceed its elevation very much).

Wellington, page 270, gives as a limit of speed for safety that point where the centrifugal force amounts to one-fourth the weight, or $C = \frac{W}{4}$, permitting a speed of sixty miles an hour on a five-degree curve and forty miles an hour on a ten-degree. His table, page 273, gives the centrifugal force as more or less objectionable and dangerous between certain limits, the inferior limit occurring long before the maximum speed is reached for which it is safe to elevate. Six and one-half inches is a proper elevation for a two-degree curve for a speed of 70 miles an hour, but 41 to 130 miles are the limits given between which the centrifugal force is more or less objectionable and dangerous, the car overturning from centrifugal force at the latter speed.

RULE 1. Assume the value given on page 322 of Wellington as sufficiently correct, for an average curve at an ordinary speed, neglecting any deduction that might be made for compensation of grades. Take this figure, 0.000593 and multiply by the cost per train-mile (T), by 365, and by the number of trains (N), being the sum of trains in both directions, and divide by the rate of interest (r), to get the justifiable expenditure (A) to eliminate one degree of central angle for an ordinary maximum

speed of 50 miles per hour on an average curve requiring 3½ inches elevation, or as a formula: $A = \frac{0.216\ T\ N}{r}$; this gives a flat value which takes no account of speed of trains.

RULE 2. For any other maximum speed, increase or decrease, the value of A in direct proportion.

RULE 3. To the value of A, obtained as above for 3½-in. elevation curve at the given maximum speed, add one-third for a curve requiring 6 in. elevation; deduct one-third for a curve requiring 1 in. elevation, and make intermediate degrees of curve in proportion.

FORMULA.

Combining rules 1, 2 and 3 into the form of an equation, we have Equation (1), $A = \frac{T \cdot N\ V\ (E + 4)}{1732\ r}$ as the value of A for any maximum speed for any degree of curve elevated according to the formula $E = .00066\ DV^2$ and corresponding table on pages 61 and 62 of our Manual.

Example. What can we spend to eliminate one degree of central angle of a 2° 30′ curve; maximum passenger train speed (for which track is elevated) 60 miles per hour; number of passenger trains in each direction 15, number of freights each way 15, making a total of 60 trains a day; cost per train mile $1.60; money at 4 per cent interest; and assumed that freight trains will run at a speed to give about the same economy and safety in operation as passenger trains at 60 miles. Then in Equation (1) we have T = 1.60, N = 60, V = 60, E = 6, r = 4 per cent. = 0.04, and $A = \frac{1.60 \times 60 \times 60 \times 10}{1732 \times 0.04} = \$831.40$.

Were the degree of curve 0° 25′, requiring an elevation of one inch, the value of A would be one-half, or $415.70. If the maximum speed were 50 miles an hour instead of 60, the value of A for 3° 38′ curve requiring 6 in. elevation would be $692.80; and $346.40 for a 0° 36′ curve of 1 in. elevation. If the rate of interest were higher, the values of A would be correspondingly less. Wellington, on page 323, uses 8 per cent interest, which would reduce the values in this example by one-half.

Example 2. Given a branch line in the mountains with considerable traffic: What can we spend to eliminate one degree of central angle on a six-degree curve, maximum passenger train speed for which track is elevated, 30 miles per hour, freights to run at a speed to give about the same economy and safety in operation, number of trains each way 15, total number 30; cost per train-mile $1.20; money at 6 per cent interest?

Here we have, T = 1.20, N = 30, V = 30, E = 3½, r = 0.06, and $A = \frac{1.20 \times 30 \times 30 \times 7.5}{1732 \times 0.06} = \$77.90$.

If it is assumed that the cost of operation increases according to the square of the speed above 50 miles per hour, the corresponding formula for speeds above 50 miles per hour would be,

Equation (2), $A = \frac{T\ N\ V^2\ (E + 4)}{86600\ r}$

The maximum speed in the above formulas is understood to be the speed for which track is elevated according to the formula, $E = .00066\ DV^2$ and accompanying table on pages 61 and 62 of the Manual; but if important trains are likely to run at considerably higher speed, it might be well to make an increase in the value of A.

Finally, as a rough check or sidelight on calculations, the following is suggested:

Add up the total degrees of central angle on the whole line or division, as at first built or projected. Then consider how much more money the road would probably be worth to the company in its present financial condition were all the curvature eliminated and the line straight from one end to the other; divide this amount by the total number of degrees of central angle.

*NOTE. In support of the proposition that the objections to curvature increase with the speed of trains, and are not sufficiently balanced by the fact that we use lighter curves for higher speed, we may note the following illustration of an extreme case of the increased liability to derailment:

*It would be interesting to investigate how far the springs act in holding down the wheels and modifying the movements above noted.

Given a train going at 30 miles an hour on a 10-degree curve. Suppose a wheel on the outside of curve strikes an obstruction that causes it to rebound or bounce a vertical distance of one inch; then (Trautwine, page 348, Ed. 1902) we figure as follows:

Time of rise (or rebound) $= \sqrt{\frac{.0833}{\frac{1}{2}\ g}} = 0.072$ seconds $= .0012$ minutes. The distance traveled during the rise at 30 miles per hour, or one-half mile per minute, will be 2640 × .0012 = 3.2 ft., and it would have gone 6.4 ft. before dropping back to a level. When it had traveled three-fourths of this distance, or 4.8 ft., it would still be elevated (in the air) about ¾ in. The wheel will have traveled straight on in a tangent, however, while the rail has curved inward in this distance 0.02 ft., or, in reference to its original position on the rail, the wheel is elevated ¾ in. and has moved out from the center of track ¼ in.

Similarly, suppose the velocity is 60 miles per hour instead of 30, and the wheel strikes the same obstruction, the vertical rise or bounce will be 4 in. instead of 1 in. But suppose the degree of curve is 2° 30′ instead of 10°, requiring the same elevation of rail, 6 in. as a 10° curve for 30 miles an hour. Similarly as above the time of rise will be $\sqrt{\frac{.333}{\frac{1}{2}\ g}} = 0.144$ seconds $= 0.0024$ minutes. The distance traveled before it would get back to a level would be 25.3 ft.; and at a distance of 19 ft. it would still be elevated (in the air) about 3 in. and will have gone forward on a tangent, moving out from the center of track a distance of 1 in. (or exactly 0.94-in.); and going at 60 miles an hour!

If in the above example we had used the same degree of curve for both speeds, we would have found the movement away from the center of track sixteen times greater for 60 miles an hour than for 30. Therefore, neglecting any modification of movements occasioned by the repressive action of the springs, the joining together of one or more axles in a truck, one or more cars in a train, etc., we may say that when a wheel on the outside of a given curve strikes an obstruction that causes it to bounce, the vertical movement will be as the square of the speed, but the side movement due to the centrifugal force will be approximately as the fourth power of the speed.

If, as in the above examples, the degree of curve is reduced for the higher speed so as to give the same elevation of outer rail for both speeds, the side movement will be approximately as the square of the speed.

Steam Pile Driving

That the force applied must be greater than the resistance, is a primary principle in driving any pile, no matter what make or size. If, for instance, a 3,000-lb. weight is placed on top of a pile, the pile goes down until the resistance equals 3,000 lbs. and then stops.

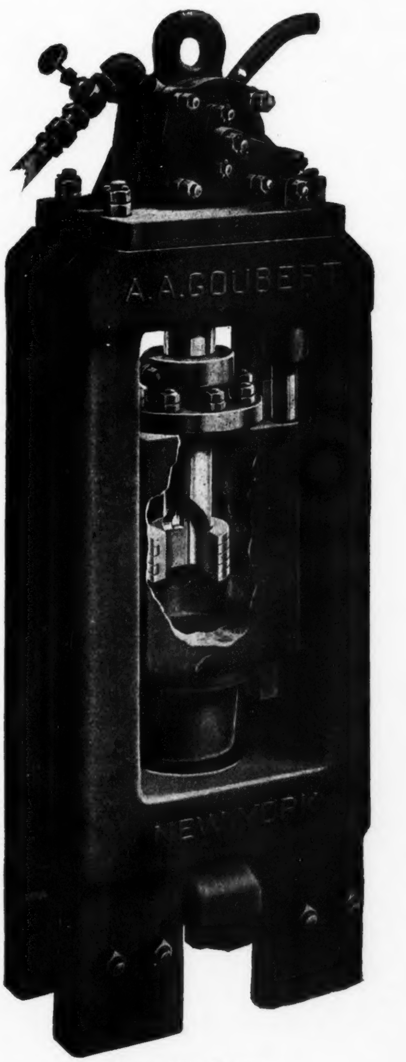
If the force is applied as a blow, there is a lateral vibration of the pile and a corresponding lateral compression or flow of the soil which lessens the resistance, but absorbs part of the driving force in doing so. This vibratory effect is greater at the top of the pile, becoming less and less as the pile proceeds downward. If the blows are far apart, the soil settles back against the pile, and the work expended laterally in freeing it is

lost, but if the blows are repeated at very frequent intervals the soil is kept "alive" and the work of driving is made much easier.

The force of the driving blow is the product of the weight and the velocity at the instant of striking, but a heavy weight and a short fall is more effective than a light weight and a high fall. A light blow affects only the top of the pile, while the heavier the blow the further downward it is felt.

In the case of the drop hammer, as the pile is driven deeper and the resistance proportionately increased, the height from which the hammer can be dropped, and its consequent effect, also increases, so that the adjustment of the two might be called practically automatic. The force of the blow, however, is limited by its destructive effect upon the pile, and so much time is lost between blows that the work is slow. The number of blows obtainable, six to ten per minute, is not sufficient to prevent the settling back of the earth as in the case with a steam hammer working rapidly. A light blow of the latter is therefore as effective as a heavy blow of the former.

There are essentially two distinct types of steam pile driving hammers. In the first, the steam acting under a piston raises a weight which is allowed to drop by gravity. The stroke, being necessarily limited to keeping the apparatus within practical size, ranges from 20 ins. to 30 ins. This being also the height of the fall, a heavy drop must be used to secure a sufficient force of blow, especially that there is probably a slight retardation of the fall due to back pressure of the steam against the piston during the period of exhaust. Notwithstanding this, a speed of about 60 blows per minute is attained. This is a great improvement over the six to ten of the ordinary drop hammer, but the considerable size of the hammer is a drawback in this type, a 3,000-lb. hammer, delivering a blow of 7,400 ft. lbs., being over 12 ft. high.



Steam Pile Driver.

In the second type, a double-acting steam cylinder is used. After lifting the weight the steam is reversed and applied on top of the piston to propel the hammer downward at a greater speed than would be obtained from gravity alone. A shorter stroke can be used and a greater number of strokes obtained. A hammer of this type can easily be made to deliver 200 blows per minute.

In analyzing the performance of this type, it is a common error to figure the pressure upon the piston area as if the pressure were a mass, the arresting of which produces an impact reducible to foot pounds. This is erroneous; the action of the steam upon the piston is only to propel it at a velocity proportionate to its pressure and to the freedom of its admission to the cylinder, and as this force is applied to a falling weight its effect is to accelerate the velocity of the fall, so that for a given area and a given pressure, the greater the weight, the greater the dynamic effect of the blow.

On the other hand, the greater the velocity the greater the impact, and this is in proportion to the square of the velocity at the end of the fall; if we double the velocity the impact is four times as great.

As a concrete example, if we suppose a 1,000-lb. weight falling 2½ ft. velocity at the end of the fall will be 12.6 feet per second and the impact 2,466 ft. pounds, but with double the velocity the impact will be 9,864 ft. pounds, equal to the same weight of 1,000 lbs. falling from a height of 10 ft.

If the moving parts of light weight, the hammer will be very ineffective. For this reason it is customary to attach a heavy weight or ram to the lower end of the piston rod. This weight is raised by the pressure of the steam under the piston and the admission of steam reversed to the top of the piston propels the weight downward at great velocity to strike the blow.

The work is very severe, especially when driving steel sheet piling, and might be compared to a hammer striking a full blow on a steel anvil. The concussion has a tendency to loosen all bolts, nuts or fastenings. Such parts should be eliminated as far as possible from the moving parts. The percussion reverts to the piston rod, which, being of comparatively small area, is strained much beyond its elastic limit. Repeated blows cause it to fracture as if it were of glass, often after only a few hours of work. The delicate valve mechanisms are subject to continual breaking and the hammer may be more often undergoing repairs than in actual service. The advantages may be more than offset by continual trouble. It is true that this criticism applies in a measure to the steam drop hammer of the first type, but in a much greater degree to the steam-driven hammer of the second type.

It is therefore necessary in order to secure continuous service that a steam-driven hammer be constructed with the fewest possible parts liable to jar loose, such as bolts, nuts, cutters, valve parts, etc. All such parts should be in plain sight during operation so that the loosening is easily detected and remedied before the occurrence of actual damage. The hammer proper or ram should be free from other parts at the moment of striking, so that the percussion cannot affect piston rod or valve gear. Its weight should be as great as consistent with the design, the work to be done and the pressure of steam. Its mass and the sectional area of the striking part should be such as to easily absorb the reaction without straining the fibre of the metal, and lastly, all parts should be of steel.

All these points have been well worked out in the construction of the Goubert pile driving hammer, which is illustrated.

In this machine, the cylinder, a heavy solid steel casting is the hammer that strikes the blow; it slides freely on guides which are part of the frame and its mass is such as to readily absorb the effect of percussion. Its lower end or pene strikes upon a loose anvil or dolly block, also of steel, that rests on top of the pile and the pene is of such large area as not to be injuriously upset by the effect of the repeated blows.

The piston and the piston rod are stationary, and rigidly connected to the valve chest which in its turn, is securely bolted to the frame; channels bored through the piston rod admit the steam, alternately above and below the piston. The admission of steam is controlled by a rotary valve in the chest above the piston rod. This valve is actuated by a radial arm to the end of which is hung a heavy plunger.

The cylinder has no permanent connection with the valve gear. At the end of the up stroke it strikes the blow. The percussion causes the plunger to suddenly fall, thereby reversing the valve, opening the exhaust and admitting steam for the up stroke. A buffer spring limits the fall of the plunger. The parts are all heavy, of ample strength, easily accessible and renewable.

All parts including the frame are of open hearth steel and practically indestructible. The frame is arranged to slide on leaders if required and an eye is provided on the top of the chest for suspension from a derrick. The length of dolly block is such as to permit of driving two interlocking sheet piles at the same time and it is made in the form of a cross to readily drive corner piles. It is also arranged to take in round piles from 9 ins. to 20 ins., according to size of hammer.

Increased Life For Railroad Ties

With the diminishing supply of hard wood suitable for railroad ties, and the rapidly increasing demand, the problem of finding some efficient substitute is becoming increasingly urgent. Taking the statistics for 1907 (1908 not being a normal year) we find that the total number of ties used in the United States was 153,,700,000, of which 15 per cent were used under new track and 85 per cent for renewals under old track. Of the total number, 40 per cent were oak, 22 per cent southern pine, and the remaining 38 per cent was made up of about fifteen other kinds of wood. The total cost of these ties represented the enormous sum of $78,500,000 or approximately $300 per mile of road, including street and interurban roads. Of the total sum, $33,199,200 was paid for oak ties, $17,241,140 for southern pine ties, and the balance, $28,059,660 for ties of miscellaneous woods, mostly the softer varieties.

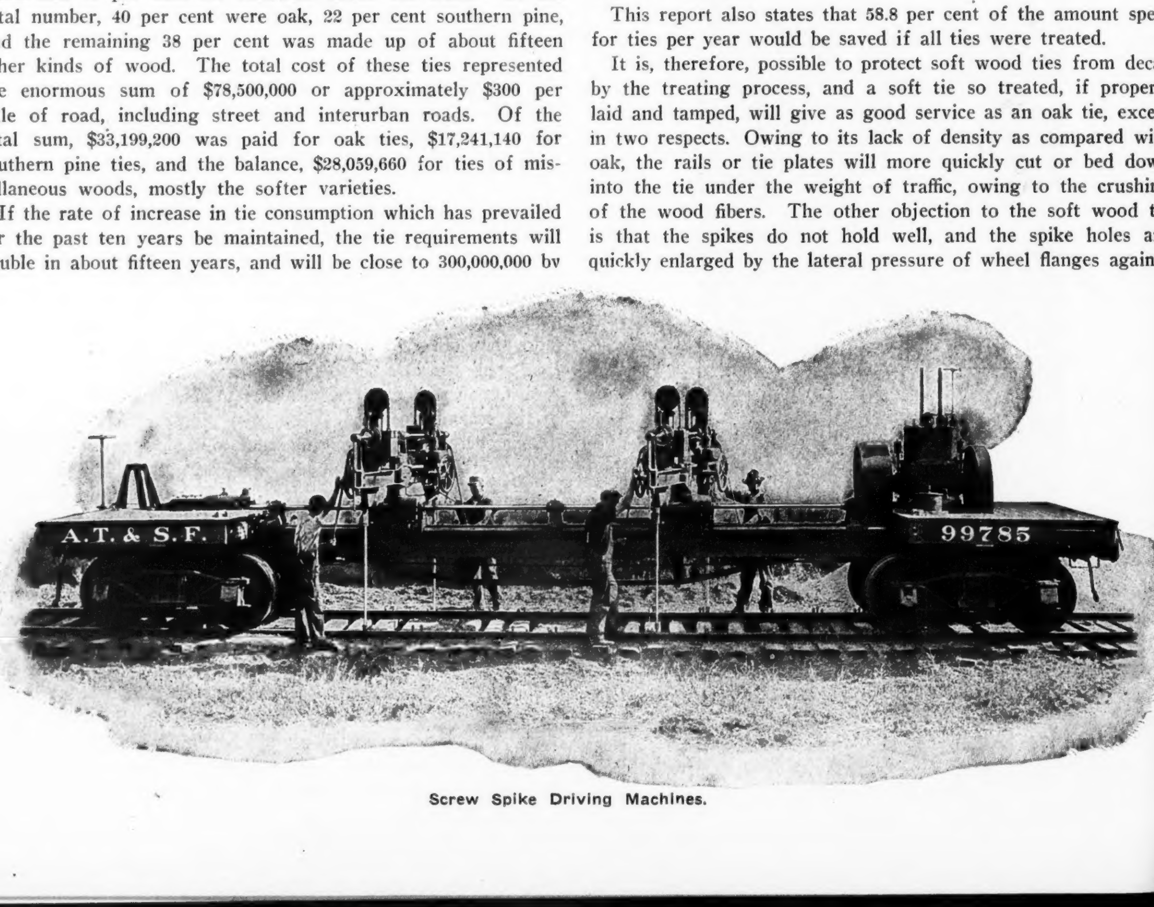
If the rate of increase in tie consumption which has prevailed for the past ten years be maintained, the tie requirements will double in about fifteen years, and will be close to 300,000,000 by 1925. This increase alone, even were the supply adequate, would result in a considerable increase in the cost per tie, and when the diminishing supply is taken into consideration the cost per tie by 1925 will surely reach a figure which will seriously handicap new construction and make the maintenance of existing track a serious drain on the earnings of the railroad companies. If this is true of all tie timber in general, it is more serious in regard to oak and other hardwoods, and the cost of these bids fair to become prohibitive in the near future. The railroads, therefore, must turn their attention to the use of cheaper kinds of timber, and this means the softer varieties.

These softer varieties include fir, cypress, hemlock, spruce, birch, redwood, the less valuable species of pine, etc. By treating with creosote or other decay-arresting chemicals, these woods can be made to give a longer useful life, as far as general decay is concerned, than oak and other hard woods which are untreated. The United States government reports give the following data as to the relative life of untreated and treated railroad ties:

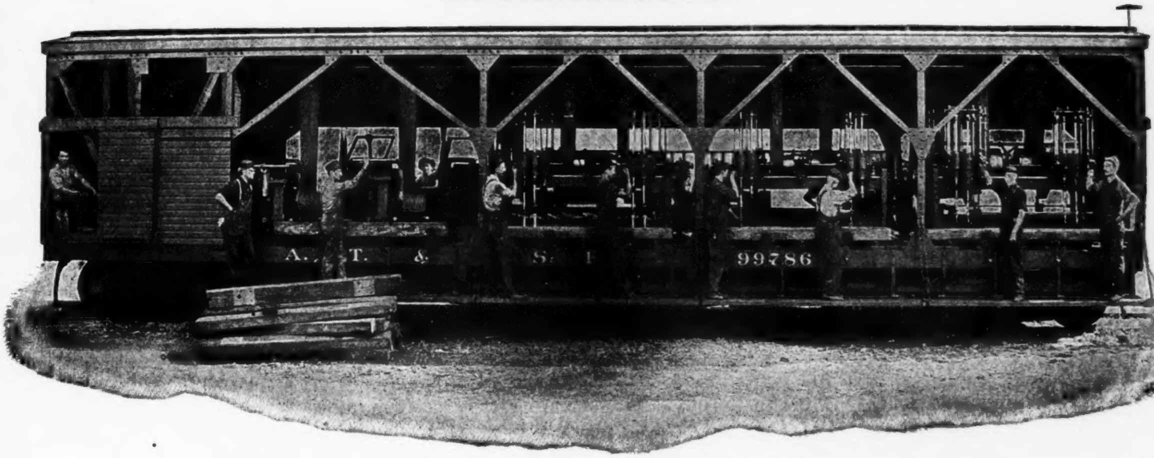
Wood.	Untreated—Years.	Treated—Years.
Redwood	12	20
Cedar	11	20
Cypress	10	20
White Oak	8	20
Long-leaf Pine	7	20
Chestnut	7	15
Red Fir	7	15
Burr Oak	7	15
Tamarack	6	15
Spruce	6	14
Beech	5	20
Birch	5	15
Maple	5	15
Hemlock	5	15
Black Oak	4	15
Loblolly Pine	4	14
Lodge Pole Pine	4	14

This report also states that 58.8 per cent of the amount spent for ties per year would be saved if all ties were treated.

It is, therefore, possible to protect soft wood ties from decay by the treating process, and a soft tie so treated, if properly laid and tamped, will give as good service as an oak tie, except in two respects. Owing to its lack of density as compared with oak, the rails or tie plates will more quickly cut or bed down into the tie under the weight of traffic, owing to the crushing of the wood fibers. The other objection to the soft wood tie is that the spikes do not hold well, and the spike holes are quickly enlarged by the lateral pressure of wheel flanges against



Screw Spike Driving Machines.



Machines Preparing Ties for Screw Spikes.

the rails. The gauge is, therefore, maintained with difficulty and the spikes must soon be redriven. The life of the soft wood treated tie is measured, not in terms of general decay, but by its effective holding power on the spikes.

Mr. J. W. Kendrick, vice-president of the Atchison, Topeka & Santa Fe Railroad, has, after several years of study and experiment, worked out and patented a method by which the advantages of the low first cost and long life of the treated soft wood tie can be taken advantage of, and the objections overcome.

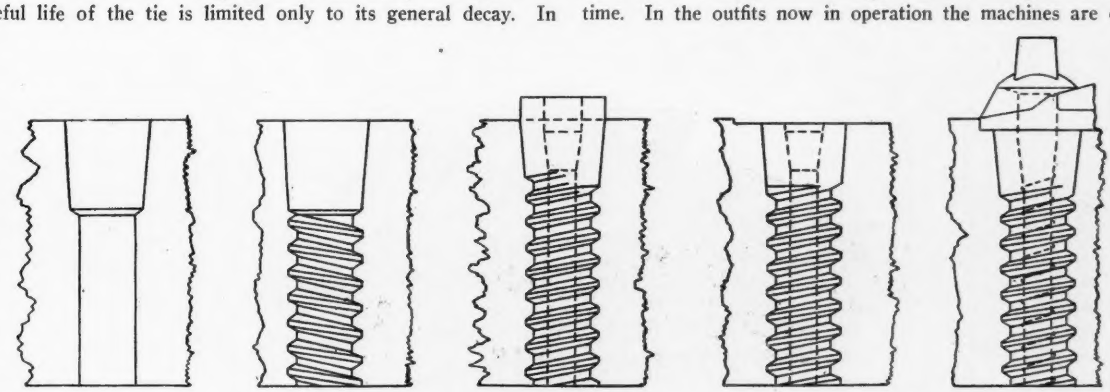
The tie, before being treated, is put through a series of machines which perform the following operations: The first bores four holes 1¼-inch diameter, two at each end, spaced five to six-inch centers, according to the width of the foot of the rail used. These holes are "staggered" and do not come opposite each other on the same end. All four holes are bored at once in an automatic machine. The tie passes to the next machine, which cuts a coarse screw thread in each hole. It passes then to a machine which screws into the holes, four oak plugs threaded to fit the screw previously cut in the holes. The plugs are tapered or enlarged at the top and are forced in very tightly against this taper. The tie then is passed to the last machine, which gains or "daps" off the projecting ends of the plugs and also faces off the tie to parallel surfaces to receive the tie plates. The tie is then put into the treating tanks and the chemical is forced into the wood under 200 pounds' pressure, giving a very deep penetration. The advantages secured by the use of the hard wood plugs are many. Tie plates and rails are supported by them, the end grain of the oak plugs giving much greater resistance to compression than is offered by a solid oak tie, and six to eight times the resistance of the soft wood tie alone. As the plugs are indefinitely renewable the useful life of the tie is limited only to its general decay. In other words, it may be retained in service until its strength has been entirely utilized. This means close to 100 per cent efficiency in tie life.

The holding power of screw spikes in these hard wood plugs is so great that the spikes have frequently been twisted off without stripping the hold of the spike in the plug.

In Germany practically all new track, and a large percentage of renewal work, is done with soft wood plugged ties and with screw spikes. The German method of plugging does not offer the support to the rail given by the Kendrick method and is, therefore, inferior to it, as this is one of the most important features. Mr. Kendrick has in his office a section of a plugged tie which has been in service under a European track for twenty-six years.

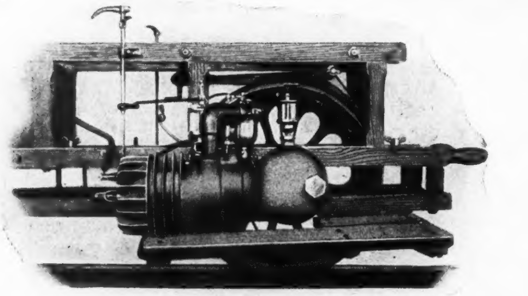
While the tie plugging machinery can be located at the treating plant or at some central point from whence the ties may be distributed along the line, the Santa Fe Company has preferred to have the machines mounted on cars for two reasons. At their treating plant at Somerville, Texas, where 50 to 75 million feet of ties are carried, the untreated ties are piled beside switch tracks in yards covering a very large area. Instead, therefore, of bringing the ties to the plugging machines, the machines are brought to the ties, saving much of the expense of handling.

Another reason for having the machines mounted on cars is to facilitate the renewal of ties already in service. A complete set of machines as used by the Santa Fe Company consists of two multiple spindle-boring machines, two multiple spindle-tapping machines, two multiple spindle plug-screwing machines and two double-head gaining or dapping machines. These are arranged on the car in pairs, one machine of each kind on each side, so that eight ties are being worked at a time. In the outfits now in operation the machines are driven



Bored and Reamed. *Hole Tapped.* *Plug Screwed Home.* *Dressed for Tie Plate.* *Completed Rail Fastening.*

Method of Applying Screw Spikes.



Adams Engine Used on Motor Car.

by a 75 horse-power Westinghouse steam engine taking steam from the locomotive, which also moves the car. In future gasoline engines will be used and the car made self-propelling.

In addition to the machines above noted, there is a screw spike-driving outfit mounted on another car. This consists of one or more machines, each having two radial arms, each arm being provided with a geared driving head and a long spindle reaching down to the ties. Each spindle has a square socket chuck at its lower end to engage the spike heads. The radial arms cover an arc sufficient to reach four ties. A power-traversing mechanism moves the heads lengthwise of the car, so that fourteen ties can be reached before it becomes necessary to move the car ahead. An adjustable friction device on each spindle gives any desired driving force and spikes can be driven so hard as to twist them off in the wood.

In reworking old ties out on the road, the old cut spikes are drawn and the ties taken from beneath the rails and passed through the machines on the plugging car and immediately replaced in the track. The spike-driving car follows the first car and drives the screw spikes into the replaced plugged ties. In this way ties which are spike worn but otherwise sound are given a new lease of life and their endurance doubled or trebled.

As the spike holes are accurately spaced in the boring machine, the track is left in perfect alignment and absolutely true to gauge. Provsion is made in the machines for required variations of gauge for curve work, etc.

A two head, four spindle spike-driving outfit, will lay half a mile of track in nine hours, and the machine equipment on the other car will plug the ties required for the same distance in the same length of time.

Designs for a lighter spike-driver having one or two heads and either two or four spindles are nearly completed. These are intended for section or division repair work. They will be driven by a 20-horsepower gasoline motor, will be self-propelling and will be used for general track work, taking the place of the light gasoline section cars now used on some roads.

The entire line of tie plugging and screw spike-driving machinery developed by Mr. Kendrick and other Santa Fe officials is now being built by Greenlee Bros. & Co. of Chicago and Rockford, Illinois, who are prepared to supply them to any other roads who may wish to adopt the Kendrick system.

Inspection By Motor Car

We are now using the motor car for inspection, because it has been perfected to meet service requirements and to overcome operating difficulties. It has always been recognized that the signalmen, linemen, lampmen, roadmasters and all inspectors could superintend the work to better advantage, if it were possible to reach any point on their section without delay. Instead of waiting for a local train or taking long walks from point to point, tney now use the motor car and thereby save many hours time each day.

From the officials' standpoint, the motor car is appreciated more for the latter than for any other reason. The importance of constant and close inspection is made possible and a reduction in the length of section assigned to one man did not provide for a solution of the problem, because, while good inspection means economy in maintenance, there was a limit to the reduction in section of track per man which also had to be considered. We have concluded that the motor car is an economic proposition since its mechanical perfection.

Some of the important features of the motor car, which are of particular interest to owners will be briefly discussed in connection with the car illustrated in the two accompanying photographs.

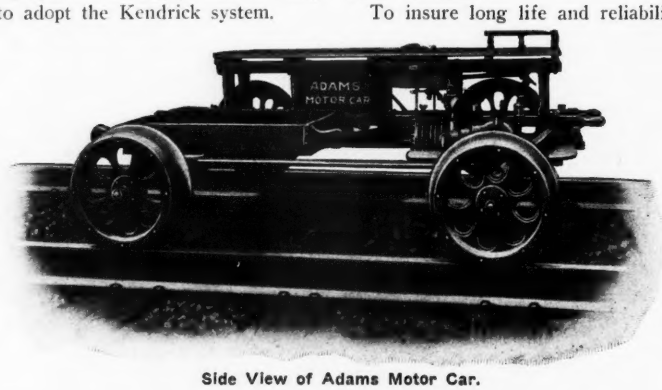
Before taking up the construction we should note the convenience of operation and also safety and economy of operation. A simple compression relief facilitates starting and enables coasting, and also by leaving the compression relief closed it can be used as a brake. A box is built in the frame to carry batteries, spark coil, switch and tools, and by locking the box the owner can prevent the car from being used in his absence. Before you use the motor car you are not in such a good position to realize or appreciate these matters of convenience.

It can be specified in advance that the maximum speed must be anything under thirty miles and safety can in this way be assured by limiting the speed. In the way of economy, seventy to ninety miles are run on each gallon of gasoline and through strength of material and few moving parts, a saving in the cost of maintenance is secured.

The above description applies to the Adams Motor Car, handled by Burton W. Mudge & Co. The engine is a two-cycle reversible, air-cooled, direct-connected motor with sight feed oil cups and Schebler carburetor and jumpy spark ignition. It is claimed that this is the simplest and most satisfactory design of engine for the service for which it is intended, as it has no valves, cams, gears, or chains to give trouble. Control is had by throttle lever, spark lever and relief lever for starting and coasting.

All working parts are enclosed to insure their working in oil, thus preventing undue heating and wear. The cylinder head and crank case joints are metal to metal, with the result that there is no packing to work loose or blow out and cause loss of compression. The frame consists of six white ash rails, with cross arms iron bound, clamped with eye-bolts to middle rails of frame.

To insure long life and reliability all bearings and parts are



Side View of Adams Motor Car.

generously proportioned, the main engine bearing being one and three-eighths inches in diameter by four and one-half inches in length and all materials are thoroughly tested for strength and elasticity.

The weight of the car illustrated is 270 pounds, with four wheels and tray and is 245 pounds with only three wheels. The car is balanced and weight distributed so that one man can handle it quickly.

Bucyrus Unloading Plows

For many years the ballast plow has been in very general use by railroads and the design used has remainder unchanged. Within the last year, however, new types have been introduced which should be of considerable interest to roadmasters and other officials. A company responsible for innovations is the Bucyrus Company of South Milwaukee, Wis.

The first of these plows to be mentioned is the Side Unloader, illustrated. The special feature of this plow is the curved moldboard as against the straight type of the older plow. The great advantage of this design lies in the fact that the entering angle is greatly reduced, thus minimizing the transverse pressure of the material against the forward end of the plow. The moldboard gradually curves outward as the material has been partly pushed off the car, thus distributing the pressure instead of concentrating it on the forward end, as is the case when the moldboard is straight. The natural results of this are, first, the prevention of the breaking of the stakes and, second, a substantial decrease in the necessary draft rope pull. The above cut, besides showing this feature to advantage, gives an idea of the substantial construction of the plow, the nosepiece casting, the all-steel construction and the heavy-wearing strap on the bottom.

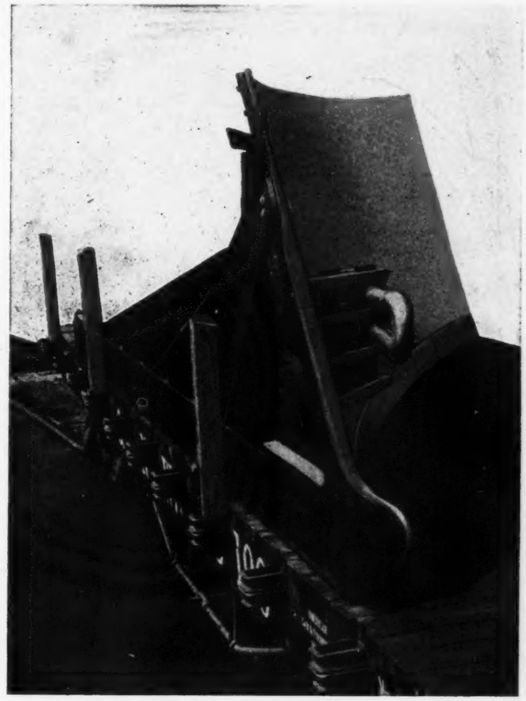


Fig. 1.—Style 4 Bucyrus Side Plow Showing Curved Mouldboard.

In the past the principal difficulty with centre plows has been felt in connection with the method of shifting the weight from the pilot to the main plow and vice versa as the amount of material to be dumped may require. In the Bucyrus plow the older counterweight method has been directly improved upon by the means of an ingenious lever system. The pilot is driven directly from the main plow by means of braces from the nose of the latter to the forward arch of the former, thus dispensing with the unusual strain on the arches and on the lug of the pilot. This fact enables the draft rope pull to be communicated directly to the main plow by means of two heavyv draft bars, pin-connected to the bell crank, which is pivoted to the nosepiece of the main plow. The pin connecting the upper draft bar to the bell crank is adjustable. From the horizontal arm of this bell crank a link extends to the upper framework of the pilot plow, thereby converting part of the draft pull into an upward pull on the main plow and into a downward

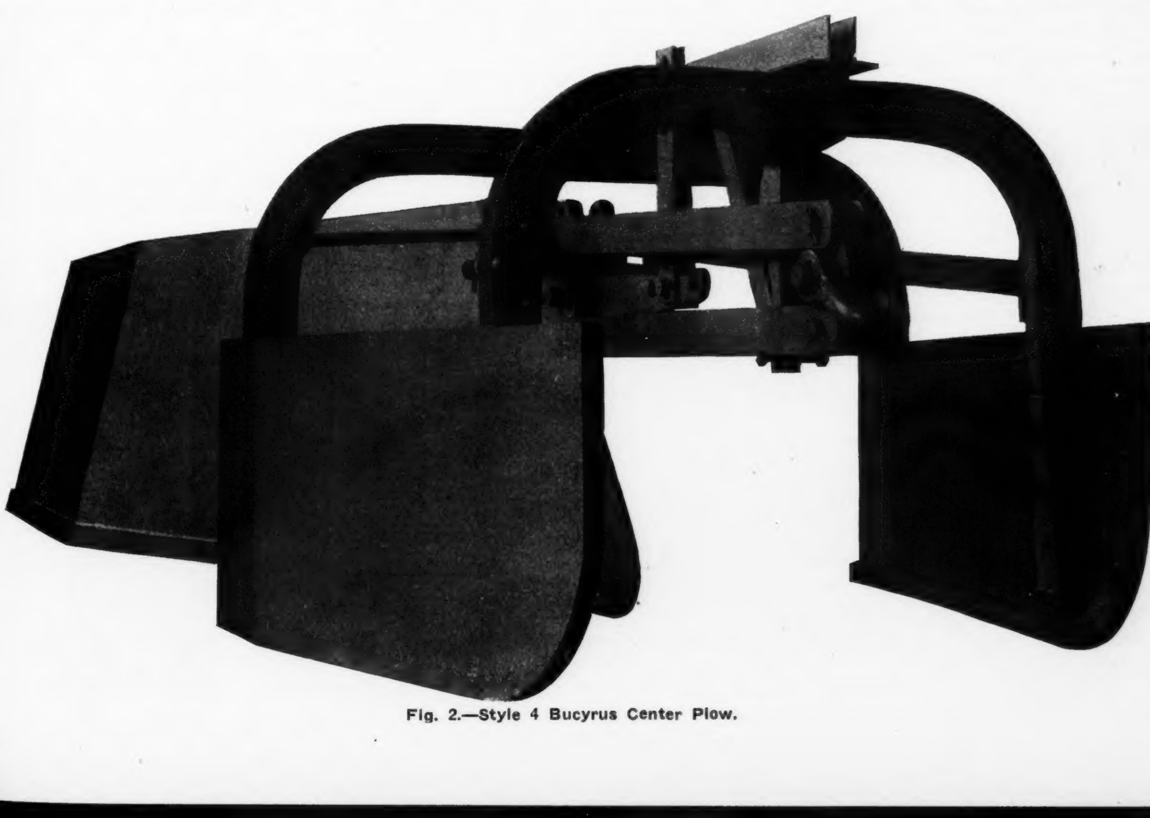


Fig. 2.—Style 4 Bucyrus Center Plow.

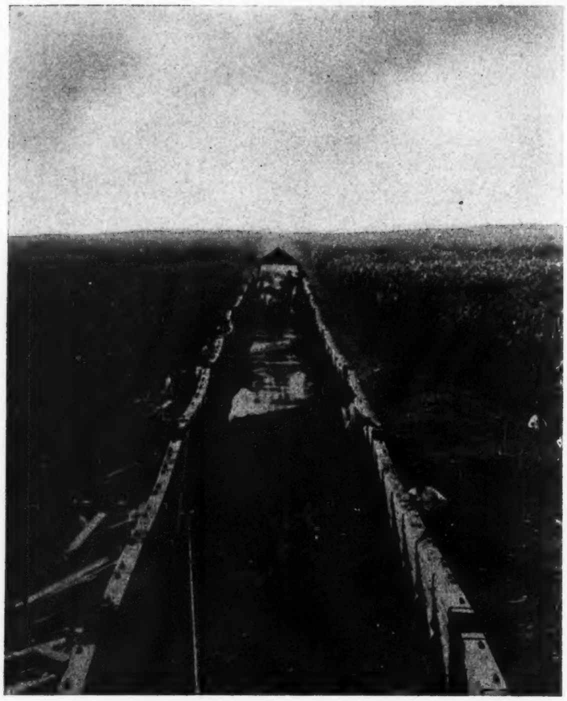


Fig. 3.—Bucyrus Side Plow at Work on Erie R. R.

pull on the pilot plow. This downward pull is a constant fraction of the varying draft rope pull; and thus, when the plow passes from light material into heavy material the increased draft rope pull increases the downward pull on the pilot, and also relieves the drag of the main plow over the car floor. This is shown to advantage in Figure 2. Holes are supplied in the bell crank by means of the draft bars to vary this downward pull as desired. The automatic quality as well as the simple manipulation of this plow is a distinct advance over anything previously designed.

The Bucyrus Company within the last year brought out an improved Rotary Snow Plow and a Locomotive Pile Driver, which propels itself at a high speed, thus eliminating the heavy expense incurred by having a locomotive ever in attendance.

Panama Railroad Relocation

There is a gap of about two miles between the ends of temporary tracks that must be closed before the relocation of the Panama railroad will be open from Gatun to Gamboa bridge. This gap is between a point in the Gatun River valley about four miles east of Gatun, and Monte Lirio, a station on the south side of the Gatun River, and it is expected that it will be closed before the end of April. It is probable that concrete laying in the Spillway of Gatun Dam will have advanced to a point in April that will make it practicable to close the West Diversion of the Chagres River at Gatun, thus backing the water in the river up to 10 feet above sea level, and subjecting the present line of the Panama railroad to inundation from the freshets of the early part of the rainy season.

The line that will be available on the relocation between Gatun and Gamboa will be temporary, but can be used in case the present railroad is put out of service by the water. It will follow the contour of the Gatun River bottom land at the point of crossing tha river, which is about four and a half miles east of the Canal. The work of making the big fill and building the bridge across the river will be carried on while the temporary tracks are in service. About eight thousand feet of trestle must be driven in to the two miles between the ends of temporary track in this section and the pile drivers are now at both ends of the gap working toward one another. In addition to the gap on the section between Gatun and Gamboa bridge, there is a gap of about one mile between Miraflores and Corozal, which will also be closed during April.

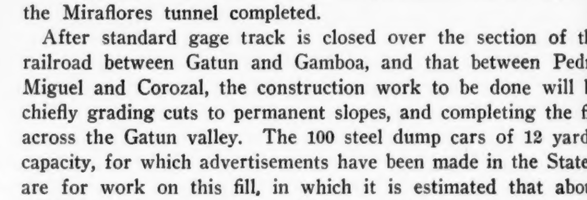
Other than the nine miles of track that will be laid through Culebra Cut, the fills that must be made across the Gatun valley, and the erection of permanent station buildings and telegraph lines, the work on the relocation is nearly eighty per cent completed. Work on the surveys was begun in July, 1906, and construction was started in May, 1907. During the fiscal year 1908 the work accomplished included 487,824 cubic yards of material excavated; 2,055,000 cubic yards placed in embankments; 15,220 cubic yards of concrete placed in permanent structures; four and one-third miles of trestle driven; 600 linear feet of tunnel driven; 13 miles of temporary track, and 7 miles of permanent track laid; the steel bridge across the Chagres River at Gamboa completed; headings on the Miraflores tunnel completed, and the work of lining the tunnel with concrete begun.

In the fiscal year 1909 the work accomplished included 914,118 cubic yards of excavation; 2,650,493 cubic yards of material placed in embankments; 17,909 cubic yards of concrete placed in permanent structures; 4 miles of trestle driven; 13 miles of temporary track, and 13 miles of permanent track laid, and the Miraflores tunnel completed.

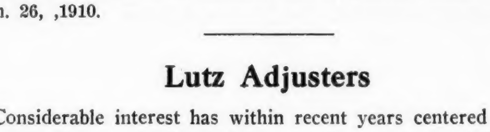
After standard gage track is closed over the section of the railroad between Gatun and Gamboa, and that between Pedro Miguel and Corozal, the construction work to be done will be chiefly grading cuts to permanent slopes, and completing the fill across the Gatun valley. The 100 steel dump cars of 12 yards' capacity, for which advertisements have been made in the States, are for work on this fill, in which it is estimated that about 3,000,000 cubic yards of material will be placed.—Canal Record, Jan. 26, ,1910.

Lutz Adjusters

Considerable interest has within recent years centered on improved adjusters for interlocking pipe lines, and especially noteworthy are the products of T. P. Lutz & Bro., of Galion, Ohio, which appear to represent somewhat advanced ideas in this particular line of railway appliances. The Lutz adjusters have been designed primarily with the idea of eliminating the difficulties encountered with the common, open-construction styles of adjusters the uncertainty of which in performing their intended functions, from possible obstructions, has become a fully recognized fault. The Lutz adjusters are typified by the enclosing of the mechanism with which the lost motion take-up is regulated, consequently avoiding all interference from snow, ice, cinders, ballast or other obstructions, thus attaining the maxi-



Lutz Adjuster, Style "A," for All Pipe Lines.



Lutz Adjuster, Style "F," for Switches.

mum degree of reliability besides relatively reducing the cost of maintenance from the amount of attention required.

The fundamental principle of the Lutz adjusters, as covered by patent right, embraces the double screw plug plan which enables adjustments of both rod length and lost motion take-up from one end of the appliance.

Lutz adjusters are manufactured in six different designs—two of which are illustrated above—calculated to meet all forms of conditions and services. The double tang-end styles supplies a long felt need in interlocking construction and maintenance, i. e., a practical device for regulating the throw of mechanically operated signals, detector bars and lifting derails, as well as switches, the importance of which is daily becoming justly apparent among signal engineers. Its use enables the discarding of many a turnbuckle and screw jaw and making the cutting of rods, the drilling of holes and the resetting of crank pins a less frequent necessity. A highly advantageous point is the fact that this adjuster can be installed at any convenient location in the line, whether pipe connected at both ends or jaw connected at crank stand.

The simplicity and durability of construction, the ease with which adjustment is regulated and the positive freedom of operation under all conditions are features which recommend the use of Lutz adjusters where economy and reliability in interlocking maintenance are considered. They have successfully undergone three years of the severest tests of usage and weather conditions and are already in use in large numbers on many of the prominent railroads of the country.

New Harbor, Wet Dock, and Graving Dock at Avonmouth, Bristol, England.*

By A. D. Swan, M. Can. Soc. C. E.

A glance at the map of England is sufficient to show why hundreds of years ago Bristol became a great port. It largely owes its greatness to its geographical position and natural harbour.

It will be recalled that it was from Bristol that John Cabot, the explorer, sailed in 1497 and planted the flag of England on the coast of North America.

The first graving dock was constructed at Bristol in the year 1625, the dimensions being 100 feet long by 34 feet wide, and it is explained in the ancient records that the dock was made of this large size so as to take in the King's ships.

The construction of the first wharves there was begun on April 27th, 1240, and since then the facilities of the port have constantly improved until they have now culminated in the construction of the great new docks at Avonmouth.

Bristol is situated on the tidal River Avon, which originally flowed through the heart of the city, but in 1809 a new course for the river was formed and the old waterway converted into a floating harbour, which is now equipped with modern wharves, elevators, transit sheds, cranes, railways, etc. The Portishead and Avonmouth Docks are situated at the mouth of the river, about five miles below the city. There are five graving docks at Bristol, and a floating pontoon dock and one masonry graving dock at Avonmouth.

The new works at Avonmouth received Parliamentary sanction in 1901, and the first sod was cut by His Royal Highness the Prince of Wales on March 5th, 1902.

Principal Features.—The general plan is shown on Fig. 1, from which it will be seen that a very large area of land was acquired in proximity to the new works to provide for future extensions and the erection of factories. Before the docks were completed, flour mills and other industrial works were already in course of construction, showing that, if proper facilities are provided, commercial enterprise at once follows.

The entrance channel or outer harbour is formed by two piers, 1,200 feet and 900 feet long, respectively, with a width between the pier heads of 700 feet, narrowing to 250 at the entrance lock.

The entrance lock is large enough to take any vessel yet built for the Navy or Mercantile Marine. Its dimensions are 875 by 100 feet, divided by an intermediate pair of gates into sections of 300 feet and 575 feet long, respectively. There is a depth of 46 feet of water on the sill at mean spring tides.

The main basin of the wet dock is 1,120 feet by 1,000 feet, with two branches, each 1,800 feet long by 300 feet wide, and another branch 700 feet by 250 feet wide, from which latter there is a connection called the junction cut, 550 feet by 85 feet between the new and old docks.

To the north of the entrance lock the new graving dock is situated, and this has also been designed with a view to modern naval requirements, altar courses having been constructed at a low level in order to suit the great beam and square midship section of modern armoured ships. It is 875 feet long by 100 feet wide at entrance, and the floor is divided by intermediate caisson into sections of 547 feet and 328 feet, respectively, with 34 feet of water over the sill at ordinary spring tides. The pumping plant is capable of emptying the dock in two hours.

Along the foreshore of the River Severn a great rubble wall or reclamation embankment, 6,000 feet long, was constructed,

*Paper in part from Canadian Society of Civil Engineers' Proceedings.

Fig. 1.—General Plan of Works.

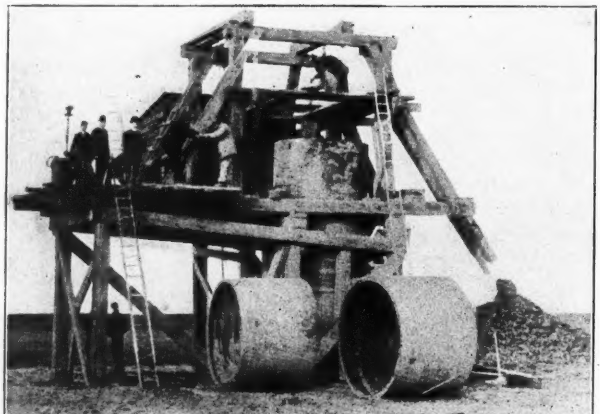


Fig. 2.—Sinking Trial Cylinder.

behind which was a width of about 2,000 feet the reclaimed land has been laid out for railway terminals.

Similarly, alongside the River Avon, from the south pier to the old dock entrance, another rubble wall was constructed, having for 700 feet of its length a concrete monolith toe, 25 feet wide, sunk to a depth of about 40 feet below water.

Construction General.—The course to be pursued in the construction of a large dock or harbour scheme requires special care, great experience, and attention, not only that some parts of the permanent work may be commenced with the least possible delay, but that the subsequent portions may be taken in hand in regular order in accordance with a prearranged plan, without calling for extensive and costly alterations in the general arrangements and in the disposition of the temporary works and plant. The success of the undertaking, from an engineering and financial point of view, is largely dependent on these arrangements.

Sinking Trial Cylinders.—Previous to the exact site of the works being finally settled, two cast-iron trial cylinders, each 8 feet in diameter, were sunk, one about the middle of the dock and the other at the entrance channel, so as to make absolutely certain of the nature of the various strata to be passed through before a rock foundation could be reached, and, although this may seem to have been an expensive operation, the information so obtained paid for itself a hundred fold. Fig. 2 shows the cylinder in process of sinking.

Setting out Works, Progress Plans, and Measurements.—The main lines were set out with two 12-inch theodolites, both of which were specially made. The steel measuring bands employed were always checked before use, and the proper allowance for expansion and contraction due to change of temperature made, as in works of this description one-eighth of an inch is of importance. Great difficulty was experienced in getting the pegs marking the principal lines to remain stationary. At many places a cluster of four 12-inch piles, about 80 feet long had to be driven, and, in two instances, even these moved. Parallel section lines, 100 feet apart, were set out on the ground from end to end of the works and correct measurements made along them for the purpose of making the monthly progress measurements, the results of which were shown in colour on the plans, and, in addition, detailed quantities were taken out.

Great Variation in Tide Level.—The main difficulties of construction to be overcome were:

(1) The enormous variation of hydraulic pressures, the range of the tide being 42 feet.

(2) The great depth to which the walls had to be carried before reaching a solid foundation.

(3) The fact that the old dock walls were founded on sand in close proximity to the new works and at a much higher level.

Temporary Dams.—The first work undertaken was to close out the sea from the site of the works, and this was done by excavating the high ground at the east side and tipping an embankment of muck, as shown by the dotted line on the general plan. Some difficulty was experienced in this, owing to the mud being so soft that sometimes tipping from wagons would go on for days without making the slightest difference, and then the ground would probably spue up and disgorge the material 100 yards away. This trouble was overcome by placing in the em-

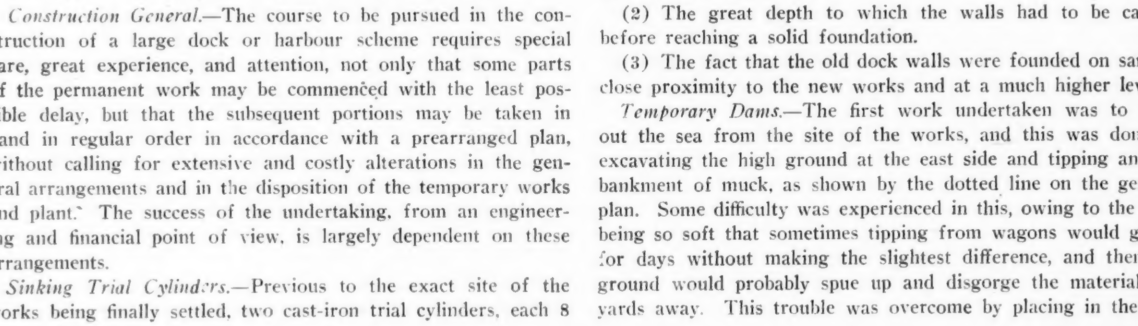


Fig. 3.—Entrance Lock and Graving Dock, Prince Edward Dock, Avonmouth, Bristol.

bankment great quantities of brushwood made into bundles. Two 3 feet diameter C.I. pipes, with sluices, were laid through this embankment, to drain off the water, and at low tide the sluices were closed and the sea shut out.

A large drainage well, about 20 feet square, was then sunk about 80 feet to the rock, and any surface leakage water was led to it in open channels about 18 inches broad.

Later, a second embankment dam was constructed in a similar manner, farther out, as indicated on the plan, and last of all a concrete monolith dam was constructed across the extreme outer end of the lock, as described later.

Excavation.—The scheme of construction was to excavate the whole site of the dock in the dry, down to a level of + 14 O. C. B. = about 24 feet below cope, at which level the trenches for the dock walls were commenced, the "dumpling," about 20 feet deep, being left in until the walls were completed. Some 4,000,000 cubic yards had to be excavated, mostly silty mud, yet of sufficient consistency to bear the steam excavators on rails on a close-tied bed. The whole of the excavation was done by mechanical means, excepting the heavily timbered trenches of the walls, which were excavated by hand. The material excavated was hauled in wagons partly by two standing engines, but mostly by locomotives (of which there were 37 employed during the work), and tipped towards the north. The land thus reclaimed from the sea was afterwards used for terminal facilities.

Rock Breakers.—In this instance practically all the excavation was of soft material, but where excavation is in rock below water, instead of using explosives to break up the rock before dredging, what is known as a Lobnitz rock breaker, which does the work without explosives, is used. It consists of a heavy chisel of compressed steel, of which the weight is from 10 to 15 tons. This chisel is fitted with a hard-cutting point, and is allowed to fall by its own weight through 6 to 10 feet from a suitable height on to the clean surface of the rock. The cutter breaks its way into the surface rock, partly pulverizing it and partly breaking it. The whole force of impact thus concentrated on a very small surface, and has been proved to crush or disintegrate the hardest rock. If the depth of rock to be broken up is more than 3 feet, it is best to break it in horizontal layers. A single cutter machine will break up 100 cubic yards per day in average rock at an expenditure of one ton of coal, wages of four men, and the cost of oil, stores, and repairs, which does not exceed the outlay for coal and wages.

It has also been proved beyond doubt that the rock broken up by this machine can be afterwards dredged at less cost than rock which has been blasted.

Wet Dock Walls.—The trenches for the walls of the main basin were excavated between 12 x 6 pitch pine sheet piling, with 12 x 12 inch main piles at 9 feet centres, with traverse struts, etc.

In excavating the silty mud, iron skips with hopper bottoms were filled by hand labour, raised by crane, tipped into wagons, and the material conveyed to the reclamation ground. The trenches were excavated to the rock at an average depth of about 54 feet.

The walls were then constructed of concrete, prepared by Taylor mixers, which travelled on rails along the entire length of the walls, as shown on cartoon drawings Nos. 4 and 5. These mixers discharged concrete through chutes directly into the trench in the proportion of 6 to 1 in the bottom and 8 to 1 on the top, with a facing of 4 to 1 up to a height of about 14 feet below cope level.

There is at this level a corbel course of masonry projecting 4½ inches from the lower part of the wall, which has a slight batter from the toe. The upper part of the wall is vertical, faced with brindle brick work and finished with a granite cope. This construction prevents ships from rubbing against the concrete facing below the corbel.

At the back of the wall near the surface there has been constructed a culvert, 5 feet wide, with manhole openings at 100 yards intervals for the accommodation of hydraulic mains, fresh water pipes, gas and other mains, and electric cables, so that easy access might be had at any time to each or all of these.

The culvert is continued in a cast-iron pipe tunnel, 6 feet in diameter, down the walls and under the bottom of the junction cut between the old and new docks, and under the floor of the graving dock and entrance lock.

A change in the method of constructing the dock walls was necessary at the north side, where the old river channel had crossed the site of the works some 30 years ago, and where the material was exceptionally soft. It was deemed inexpedient to risk building any part of this north wall in open trench, and, for a length of 700 feet, concrete monoliths were sunk similar to those at the piers now to be described.

Entrance Piers, Monolithic Structure.—As the construction of a coffer dam to enclose the site of the entrance piers would have involved an enormous expense and considerable time, it was decided to construct the piers of concrete monoliths. These monoliths were mostly rectangular, 25 x 30 feet in plan, placed about 5 feet apart, and sunk from the surface of the ground to the rock, an average depth of about 80 feet below cope. Each monolith had four pockets or openings about 6 feet 6 inches x 8 feet 6 inches, and in starting the construction a steel, or, in some instances, a timber, shoe shod with steel was set level in its correct position on the ground, upon which the massed concrete was deposited in 3-feet layers inside wooden shutters.

As each succeeding layer of concrete was added, the increased weight caused the monolith to sink into the mud, which was forced up through the four pockets and removed by "grabbing."

Considerable care had to be exercised to see that the "grabbing" in any one pocket was not carried too far in advance of the others, otherwise the monolith would get out of level and give much trouble.

In many instances the water was pumped from the interior, but in bad ground this was sometimes inexpedient. When the frictional resistance on the surface of the monolith prevented it being sunk by its own weight, "kentledge" was added as required. In some instances as much as 1,300 tons of "kentledge" was used on one monolith, giving a frictional resistance per square foot of about 2,000 lbs.

The question of pumping out the water was a very delicate one indeed, and great judgment had to be exercised, for, if too much should be removed, the muck surrounding the monolith would, in all probability, burst in under the shoe and fill up the monolith. This would mean the re-excavation of the pocket, the subsidence of the adjacent ground carrying the timber staging along with it and the probable upsetting of the steam crane thereon.

In some instances a water jet is used to disintegrate the material at the cutting edge of the monolith, and so assist the process of sinking. This is most easily applied when the material consists of fine sand, but the process sometimes proves very inconvenient, and tends to extract more material than desired, thereby disturbing the surrounding ground.

When the monolith has been finally sunk on a hard foundation, the insides of the pockets were cleaned out either in the dry or by divers. The bottom was then sealed with concrete of good quality, and the remainder filled with concrete of less rich quality. The intervening spaces of about 5 feet between adjacent monoliths were excavated by hand and filled with concrete, which bonded into grooves formed on the outer adjoining walls of the monolith.

The writer had some experience on other works of attempting to sink a monolith 80 feet long by 18 feet wide with three circular pockets, but it was so difficult to control that the design was not repeated.

Many different designs of concrete monolith walls have now been carried out, such as single cylinders, double and triune cylinders.

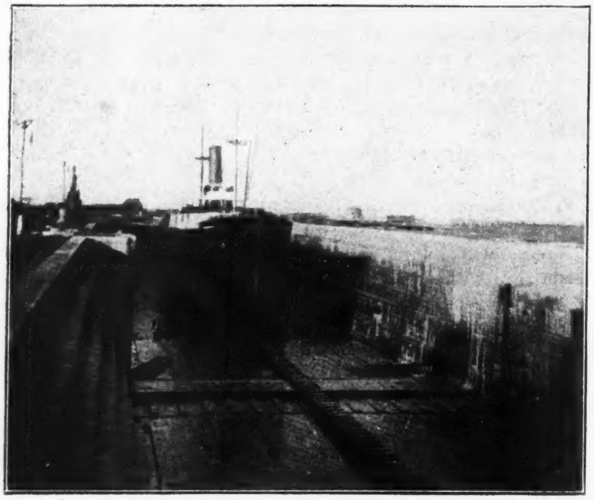


Fig. 4.—Graving Dock.

For the round heads of the two piers circular monoliths were adopted. These monoliths were 55 feet 6½ inches in diameter, and they are probably the largest of the kind ever sunk. The success of the operation depended on the design of the steel shoe. The process of sinking was exactly similar to the other monoliths, and proved highly successful.

Entrance Lock.—The entrance lock was constructed in three parts, each at different levels. The trenches for the walls beginning at the inner end, started about 18 feet below the original ground surface, and at the outer end, near the sea, the trenches were started at the surface of the ground and carried to a depth of about 65 feet.

The lock was constructed of concrete, faced with brindle brick work in panels, which was always built 3 feet in advance of the level of the concrete.

The side walls were constructed first within timber trenches in a manner similar to the dock walls, already described, skew-backs being formed at the toe to ensure a proper bond with the floor or invert. At the extreme outer end concrete monoliths similar to the pier structures were sunk from the surface of the ground right across the entrance to act as a coffer dam, and on the completion of the works the upper part down to invert level was blasted and removed, the lower part being left in to form an apron. The construction of the monolithic dam, with huge discharge culverts passing through it, was one of the most interesting and difficult parts of the work.

Along the centre of the north wall of the lock, a suction culvert, 7 feet in diameter, was constructed of brick work for pumping up the dock from the outer end when necessary, and for other purposes. After the side walls were completed, the "dumpling" between them was excavated by steam shovels to invert level. Below this, at intervals of 40 feet, trenches 15 feet wide were excavated from wall to wall for putting in the floor of the lock. The material between the trenches prevented any movement of the side walls from pressure behind. After the concrete in the 15 feet wide trenches had set, the remaining 40 feet spaces were similarly excavated.

Caisson stops were built beyond the end gates, so that the lock might be closed at any time by the floating caisson provided for the graving dock, as it is the same width as the graving dock.

In fact, the caisson was placed against the outer stops during construction to enable the outer monolithic dam to be removed simultaneously with the building of the lock gates in position.

By this means the work was completed at a much earlier date than would otherwise have been the case.

Graving Dock.—The graving dock has a length of 850 feet on the keel blocks, by 100 feet wide at the entrance and floor. From plan and sections of the dock it will be seen it is constructed of concrete with brick facing, and masonry altars, with granite for the dock coping.

In constructing the walls and invert, the procedure corresponded exactly with that adopted in the case of the entrance lock.

The graving dock is founded on a mixture of sand and gravel, the trenches in this instance not being carried down to the rock, as in the case of the wet dock walls. It was discovered, however, during construction, that there was a slight subterranean current of water from north to south underneath a vast area of this sand and gravel strata. In order to cut this off, and thus prevent any tendency to wash out the sand below the foundation, a line of cast-iron interlocking sheet piling was driven down to the rock longitudinally from end to end of the dock, making a continuous water-tight wall from the entrance to the north pier.

A very elaborate system of large culverts was devised, so that the sluices in them, which are all constructed of green-heart timber, and operated by hydraulic machinery, might be made to serve many purposes.

The following list shows the duties which can be fulfilled by the system of sluices in connection with the graving dock and entrance lock:

(1) To pump both compartments or the whole of the graving dock and discharge into the wet dock.

(2) To pump the inner compartment only of the graving dock and discharge into the wet dock.

(3) To pump the outer compartment only and discharge into the wet dock.

(4) To run off the water by gravitation to the sea without pumping from the whole of the graving dock, or to fill the graving dock from the sea.

(5) To run off the water by gravitation to the sea from the inner compartment only, or to fill the dock from the sea.

(6) To fill the graving dock from the wet dock.

(7) To pump from the sea to raise the wet dock level.

(8) To pump from a high-level intake of the lock to the wet dock, to return the locking water to the dock.

(9) To fill the lock from the wet dock.

(10) To run off the water from the lock to the sea.

The Junction Cut Between the New and Old Docks.—A more than usually interesting part of the work was the construction of the junction cut between the old and the new docks. Great care had to be taken to avoid any risk of water from the old dock breaking through to the new works, as the old dock walls had been founded at a much higher level than the base of the new walls.

In order to isolate the new basin from the old, a section of the wall nearest the new dock was first carried down to the rock, on the trench system and completely concreted. The sliding caisson chamber was then built immediately at the back thereof, and the caisson constructed in place before any further excavation was made adjacent to the wall of the old dock.

The caisson thus became an effective barrier to the flooding of the main dock in the event of the old wall collapsing, but this fortunately did not happen.

Between the caisson chamber and the old dock walls the monolithic system of construction was again chosen as a precautionary measure, in preference to open trench work. The work was conducted similarly to the pier construction, but special provision was made in the design of the shoes for the monoliths near the old walls, so that air locks could be used if ultimately found desirable. Although as much as from 1,200 to 1,300 tons of artificial weight had to be used to sink these monoliths, no resort to the pneumatic system was necessary.

On the completion of the side walls, the old dock wall at the end was cut through, blasted with tonite, and removed. Divers, diving bells, and dredgers were used for this portion of the work.

There is a swing bridge over the junction cut, which was completed at an early stage, as passenger and railway goods traffic had to be maintained over this part during the whole progress of the works. The bridge was a double line of rails, with footpath on each side, and is of the parallel lattice girder type and operated by hydraulic machinery.

Dredging of Entrance Channel.—The dredging of the entrance channel, comprising some 600,000 cubic yards, was sublet to a firm of Dutch contractors, who used a centre ladder dredger. The material dredged was delivered into hopper scows and towed out to sea a distance of some 4 miles. The whole of the crew lived on the barges, and worked regularly and cheerfully 16 hours every day, so that the contract was most expeditiously carried out. There is a considerable formation of silt at Bristol during every tide, and the culverts of the entrance lock are so designed as to scour out the channel at low water.

Lighthouses.—At the seaward end of each of the new piers there is a lighthouse constructed of granite masonry.

At the north pierhead the lighthouse shows a white flashing light every 10 seconds, and a subsidiary fixed red light. The lighthouse at the end of the south pier shows a green light, occulting every 30 seconds, and here there is also a fogbell. All the stones for these lighthouses, as, indeed, for the whole of the granite work used in the dock, were hewn and dressed exactly to the finished dimensions at the quarries in Norway from drawings prepared by the engineers, and the greatest credit is due to the Norwegian workmen for the accuracy displayed in working to those most intricate drawings.

Railway Terminals.—As previously mentioned, a great area of land (over 200 acres) has been reserved for railway terminal and commercial facilities in close proximity to the dock, and meanwhile 20 to 30 miles of railway sidings and shunting yards have been laid down. This part of the work required much study, so as to effectually serve all the different parts of the docks, and give rapid connection to the various railway companies' main lines to London and other centres.

Lock Gates.—The entrance lock is closed by gates of great height, the adjacent walls being 54 feet 4 inches from cope to outer sill level. So far as the author is aware, they are the largest and heaviest gates ever constructed, each half weighing about 250 tons. Three pairs of gates are provided, dividing the lock into an outer section of 300 feet, and an inner of 575 feet between heel posts.

The gates are constructed of steel, with iron plates and rivets outside. The heel posts, mitres, and sills are of green-heart, and on the back of the gates the iron skin is protected by cresoted memel fenders. The gates are opened and closed by direct acting hydraulic rams, working through a built-up cross head and connecting beam to the gates.

Boom-Relieving Chain Protection for Gates and Lock.—Across the lock, near the gates, there are fender relieving chains to protect each pair of gates when closed from collision with an approaching ship.

This protection chain consists of 1⅝-inch stud link fender chain, and is designed to take up the thrust of the ship gradually. To do this it has to oppose a steadily increasing resistance to the moving vessel.

When the gates are opened the chain is lowered to the bottom of the lock. Below the surface of the quay, in cast-iron boxes, there is fitted on one side an ordinary hydraulic winding engine, from the drum of which a light chain, travelling over a sheath, is attached to one end of the boom chain and passed through a steel chain stopper, the upper jaw of which is raised or lowered by a lever in order to allow or prevent the chain paying out. In the latter case the chain stretches right across the lock with a slight sag. The chain is carried through a cast-iron hawse pipe to the relieving gear. This consists of a fixed drum, above which is a similar cylinder free to move vertically; between them the boom-chain is passed.

Over each end of the cylinder is a volute spring adjustable by hand wheels and screws, by which a moderate pressure is brought to bear upon the chain. Two turns of chain are wound round the fixed drum, and a length of 10 or 12 feet of slack chain is then lightly stoppered back. The third and fourth turns are then taken in the same way with a corresponding slack of 20 or 30 feet, respectively. The end of the chain is shackled to a stout bolt secured in the masonry. The total slack must fall somewhat short of the extra length of fender chain required to traverse the distance from its original position to the lock gates. A vessel moving towards the lock gates, on coming into contact with the chain, would cause it to fleet round the drum, part the stopping, and take up the first bight of slack, thus forming three complete turns of chain round the drum and greatly increasing the frictional resistance. If this is insufficient to stop the vessel, then in like manner the fourth turn is taken up. But should the fourth turn fleet, then the last of the slack would be taken up and the fixed end would tighten all the turns on the drum, and the maximum strength of the chain would be finally exerted. Before this a vessel, with ordinary way on, would have been brought up. When it is necessary for shipping to pass in or out of the lock, the chain is lowered. When the stopper is raised, the chain passes from the winding engine round the sheave, and falls to the bottom of the lock, but to assist its fall, as well as to guide it into a groove, there is a small hydraulic capstan alongside the relieving gear, which winds in a ¾-inch hauling chain attached to the centre of the boom chain. The time occupied in lowering the chain to allow a vessel to pass and to readjust it afterwards is only a matter of a minute or so, and the protection given to the gates by means of this gradually applied increasing resistance of from 40 to 60 tons through a distance of about 50 feet is far superior to anything hitherto used.

This relieving gear has been patented by Messrs. Brown, Lennox & Co., of London, and is now being fitted to nearly all the large locks in Britain, and, it is understood, in India also.

Caissons.—The caisson for the junction cut is of steel, with iron plates designed to slide on green-heart sills in polished granite grooves, and is actuated by hydraulic machinery. The caisson for the graving dock is of the floating type, somewhat after the design of a turret-built ship. Electric pumps are fitted inside the caisson for regulating the water ballast, and it is moved out or into position in a few minutes by hydraulic capstans on shore.

EQUIPMENT.

Pumping Plant.—The pumping plant for emptying the graving dock and for other purposes is situated between the lock and

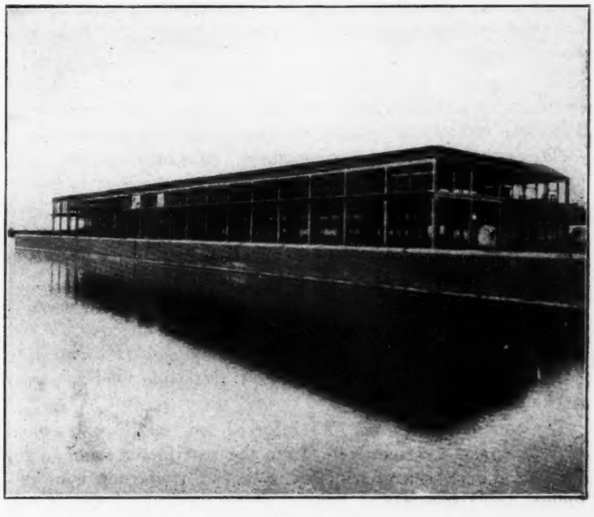
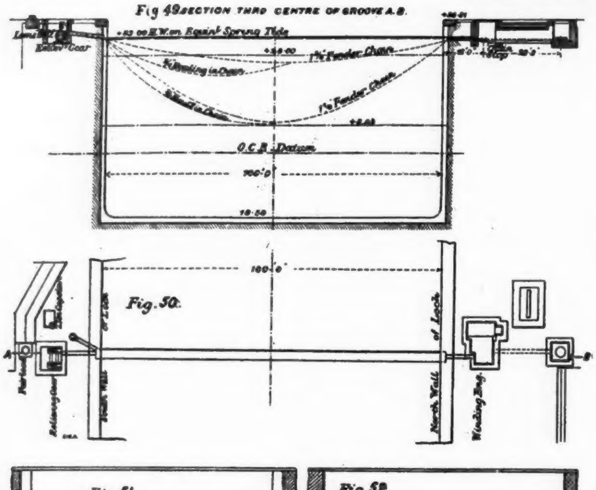


Fig. 5.—Import Sheds.



Chain Protection for Lock-Gates.

Fig. 6.—Docks at Bristol, England.

the graving dock, and is designed to empty the dock (3,350,000 cubic feet) in two hours. There are three vertical coupled compound centrifugal engines, each about 850 I.H.P. The centrifugal pumps, which are coupled direct to the engines, have cast-iron impellers, 87 inches in diameter, keyed on steel spindles. The discharge branches are 54 inches diameter, and there are two suction pipes, 38½ inches diameter. Each delivery branch is fitted with a hydraulic sluice valve operated from the engine bed-plate, the maximum lift of the pumps being 38 feet. Two of the engines are non-condensing, having cylinders 22 inches x 38 inches diameter, with a 24-inch stroke. The third engine is used for keepniging up the level of the water of the dock, and is arranged for economy to run condensing. The working steam pressure is 135 lbs. Two 12-inch drainage pumps are provided, one worked by a compound engine, the other by a Siemens motor.

The power is supplied from two Lancashire boilers, each 30 feet x 8 feet 6 inches, fitted with super-heaters and economisers, and three Babcock boilers for the non-condensing engines.

Passenger Station.—A commodious passenger station, with customs baggage examining rooms and passenger waiting rooms, is provided on the south pier, at which steamers can land their mails and passengers at any state of the tide before entering the dock. Trains from this station can reach London in about two and a half hours.

Import Sheds.—The import sheds have been constructed of reinforced concrete on the Hennibique principle. There are two double story buildings, each 500 feet long and 125 feet wide, having at the rear a covered way 34 feet wide over a double track loading way.

The foundations consist of reinforced concrete piles in groups of 2, 3, 4, and 5, respectively, from the rear to the front of the building. Each cluster of piles is braced at the top by longitudinal and transverse tie beams, which carry the columns supporting the first floor and the roof above it.

The side walls are of galvanized corrugated sheets, with continuous sliding doors. A considerable part of the roof is flat, and is used for the storage of non-perishable goods. The roof also carries the electric cranes. The part of the roof farthest from the quay face is built up of light principals and galvanized sheets. The first floor extends over the loading way at intervals, forming platforms with hatches, so that goods may be lowered into the railway wagons below. A tilting plahform is provided on the side of the building next the quay at the level of the first floor, on which goods may be deposited by the crane for distribution on this floor, but hatchways are also provided along the crane track.

Export Shed.—The export shed on the south side is 450 feet long by 100 feet wide, with a covered way along the back of the shed, 31 feet wide, with a loading platform. It is a single story building of iron and steel founded on timber piling. The roof is in transverse bays of 30 feet span, carried on steen stanchions. These latter are 12 feet 6 inches apart, and this space is spanned by 16-inch joists, which carry a gutter of built-up steel channel section. This carries the galvanized iron roof and dispenses entirely with roof principals and purlins.

From gutter to gutter there are ⅞-inch tie rods with central ¾-inch king bolts. This, it will be recognizzed, is an extremely simple and economical construction, and it has proved quite effective, as no movement was observed during the most severe gales. The end of the roof is covered with rough plate-glass. Along the sides of the sheds there is a continuous lateral girder which gives longitudinal stiffness. On the sides of the shed next to the dock this lateral girder carries cantilever brackets, with corrugated sheets to form a verandah roof.

Granary or Elevator.—The granary is erected about 400 feet back from the quay wall, the object being to permit of more sheds being constructed beside the wall.

The grain is conveyed to the granary in reinforced concrete tunnels underneath the ground. The granary is also constructed of reinforced concrete on the Hennibique system, and is capable of holding 500,000 bushels of grain. It is divided into three portions, one with six floors, each having an area of 4,200 square feet, and designed to carry at least 5 feet depth of grain; the second comprising 78 silos, 9 feet 6 inches by 11 feet feet 3 inches, and 50 feet 4 inches deep; and the third containing an elevator and weigh-house section. Underneath there is a sacking-off floor, with a distributing tunnel below, and above all a machinery floor, with conveyor bands, etc.

This building is founded on reinforced concrete piles, driven 50 feet into the ground, which are in clusters of three under the silos and of five under the columns, the groups being at 10 feet intervals. These piles are braced together by longitudinal and transverse beams, and carry the columns to support the grain floors and the silos. The outer walls are 9 inches thick normally, and rest on longitudinal beams carried on the piles.

Grain-Conveying Tunnels and Machinery.—Reinforced concrete tunnels are constructed and run continuously along the back of the dock wall in front of the transit sheds, with another tunnel branching off nearly at right angles, and leading to the granary. The tunnel in front of import shed No. 1 is 11 feet wide, and accommodates two grain-conveying bands. That in front of import shed No. 2 is widened out to take four bands. These bands are 22 inches wide, and run at a speed of 650 feet per minute. The grain is conveyed to them from the ships through chutes, and is delivered by them to four weighing machine elevators at the eastern end of the granary. These discharge into automatic weighers, which take 3,000 lbs. of grain per turn of the scale, and discharge each successive load into a boot, whence it is again raised by one of four elevators, having a capacity of 100 tons of wheat per hour. These deliver the grain to conveyor bands on the top floor, which are fitted with movable throw-offs, so that the grain can be passed into any of the 78 silos or other part of any of the six grain floors.

Chutes enable the grain to be put into sacks on the ground

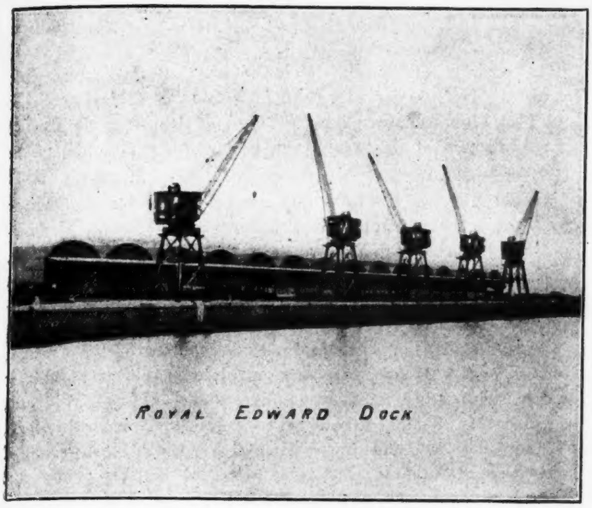


Fig. 7.—Export Quay; two 10-ton, two 3-ton and one 1½-ton

floor, or to be passed to conveyor bands in a tunnel under the basement, which communicates with the grain elevators. This admits of grain stored at any point being removed automatically to any other point.

For the despatch of grain by rail, loading ways, 26 feet 6 inches wide, covered by lean-to roofs of galvanized iron, have been built on the sacking-off floor level, on each side of the granary. For shipping grain into barges and coastwise craft, an overhead conveyor has been constructed from the granary to the dock. This will take sacks or grain in bulk, and has a capacity of 800 sacks per hour, with a belt speed not exceeding 250 feet per minute.

Electric and Hydraulic Cranes.—On the roof of each of the import sheds six movable electric jib cranes have been erected, which, from their position, can either

(1) Take cargo from the hold of the vessel and deposit it direct into cars on the quays;

(2) On to the ground floor of the shed;

(3) On to the second floor of the shed;

(4) On to the roof of the shed if non-perishable, or can transfer goods from any part of either of the floors to the floor above or below it. These cranes have a radius of 60 feet maximum and 24 feet minimum; lift 100 feet; hoist 1½ tons at 250 feet per minute; slew 1½ tons 450 feet per minute; luff in and out 90 feet per minute. On the export quay there are two 10-ton electric cranes, two 3-tons, and one 1½-tons, as shown in Fig. 7. At the graving dock there is a 25-ton crane and two 3-ton cranes.

Electric and Hydraulic Capstans.—A large number of electric and hydraulic capstans, varying from 2 to 11 tons, are provided all round the docks. These are used mostly for hauling cars, thereby saving a vast amount of locomotive shunting.

Coal Tip.—A typical hoist, as used for loading coal into vessels for exportation. The loaded cars run by gravitation from the terminal storage area on to a hydraulic turntable in front of the hoist, which automatically tips up slightly and sends the car on to the hoist cradle. The whole car, weighing from 20 to 30 tons, is then lifted by hydraulic power to a height of 40 feet above quay-level, if necessary, and the contents tipped down the chute into the hold. The empty car is then run off by gravitation at a high level while the next loaded car is being got into position. In this way about 250 tons an hour is loaded.

Materials.

Cement Concrete.—The proportions of cement to broken stone, sand, and gravel varied from three to one to fifteen to one of cement. It is not necessary to describe all the various proportions. Suffice it to say that the great bulk of the walls were constructed of eight of broken stone and sand to one of cement, with a 6-inch face of four to one.

The stock of cement was never allowed to be less than 6,000 tons in store, which, when delivered on the works, was emptied out of the bags and kept thoroughly dry and well aerated in sheds specially constructed for the purpose. Cartoon drawing No. 1 shows a cross-section of a cement shed specially designed for this purpose on other works, which, however, the author considers much too expensive a structure for such purpose.

In the interior of this shed there were three floors, one above another, on which the cement was spread. The floors were formed of 12-inch x 3-inch planks, suspended at each end by a pivot placed a little out of the centre of the plank end, so that when thus suspended the flat sides of the planks were vertical. By a mechanical contrivance, as shown in cartoon drawing No. 2, hand wheels on the outside of the shed were made to raise the planks to a horizontal position when cement was to be laid on them, or to lower them to a vertical one when it was required to drop the cement to a lower floor. Beneath the bottom floor were large hoppers, which discharged into wagons for delivery on the works. Cartoon drawing No. 3 shows a cross-section of the sheds and the system adopted at Avonmouth, where the cement was aerated by compressed air. The bins were constructed of timber in the usual manner, but the sides were pierced with holes 1½ inches diameter, 20 inches apart, in two rows near the bottom of the bin. Compressed air was supplied from a compressor to each shed by means of a pipe running the whole length of the building, with connections at intervals, to which an indiarubber pipe was attached. A wrought-iron pipe, 1 inch diameter, was provided of somewhat greater length than the width of the bins. This pipe had a solid point at one end and a stop valve and connection for the indiarubber pipe at the other end.

The operation of aerating was performed by inserting the iron pipe into the cement through one of the holes near the bottom of the bin. The air was then admitted by opening the stop valve sufficiently until the air escaped from the cement at the top of the bin. The pressure was usually about 5 lbs. to the square inch.

Washing Sand and Ballast.—As showing the practical effect of having absolutely pure sand or ballast for concrete, some 6-inch cube blocks were tested, one-half of which were made of natural, moderately clean ballast and cement in proportions of three to one, while the other half consisted of ballast from the same heap, but washed perfectly clean and mixed with the same proportion of cement. After a month the blocks were tested, and the unwashed material began to crack at an average of 13.30 tons, and crushed completely at 15.18 tons, while the washed material began to crack at an average of 20.24 tons, and crushed completely at 29.66 tons, or practically double the strength of the unwashed. The water used for mixing the concrete was fresh, and averaged about 21 gallons to the cubic yard.

Note on Decay of Concrete in Contact with Salt Water.—Where concrete is being deposited in sea water, as in the construction of a pier, there is still some difference of opinion, even amongst our most eminent engineers, as to whether the sea water in such an instance is injurious to the cement or not, and it is probably better practice to use clean fresh water. The decay of concrete in contact with salt water is due to the substitution of the calcium or lime salts by those of magnesia, the magnesia being a constituent of sea water. This action does not take place, or only to a very small extent, when the cement used is good and the concrete is sound and impervious.

Displacers or Plums.—In nearly all the walls large, rough stones called "displacers" or "plums" were embedded in the concrete to reduce the cost of the work, the saving thus effected being as much as from $1.00 to $1.25 per cubic yard, and there is also the further advantage that the more displacers the greater the weight of the wall. Where the concrete was being deposited in heavily timbered trenches, with struts at about 9 feet centres,

the timbers prevented the displacers being laid regularly along the length of the wall, and confined the extent to which they could be used to about 6 to 8 per cent. of total bulk. In open work the author has seen from 20 to 35 per cent. used.

Admission of Water to Docks on Completion of the Works. The water was admitted to the docks through two 3-feet diameter cast-iron pipe syphons, laid from the entrance channel to the nose end of the graving dock, at high tide, so as to prevent excessive silt from getting in. Approximately, about one foot depth of water was admitted each day. This represented about 35,000 tons weight.

Cost of the Works.—The total cost of the works was about £3,500,000, but, taking the relative cost of work in this country for comparison, this would have been fully double, or approximately about $35,000,000, in Canada. When the works were in full swing, about $10,000 worth of work was executed each day.

The principal contractors were:

Messrs. Sir John Aird & Co.—General work.

Messrs. Sir W. G. Armstrong, Whitworth & Co.—Lock gates.

Messrs. The Motherwell Bridge Co.—Caissons.

Messrs. Tannett Walker & Co.—Penstocks and hydraulic machinery.

Messrs. Tangyes, Limited—Pumping plant.

Messrs. T. B. Cooper & Co.—Railway terminals.

Messrs. Alex. Findlay & Co.—Swingbridge.

Messrs. Brown, Lennox & Co.—Fender chains and relieving gear.

Messrs. Carrick & Wardale—Caisson hauling machinery.

Messrs. Musker & Co.—Capstans, etc.

Messrs. The New Conveyor Co.—Grain conveying machinery.

Messrs. Higginbottom & Mannock, Limited—Electric roof cranes.

Messrs. Stothert & Pitt—Shore cranes.

Messrs. Johnson & Phillips—Electric lighting.

For several years over 2,000 workmen of all classes were employed daily, and a large staff of assistant engineers, pupils, and inspectors.

Engineers.—The engineer for the works was Mr. W. W. Squire, M.I.C.E., engineer to the Bristol Docks Committee, through whose courtesy the author is permitted to give this paper. The consulting engineers were the late Sir Benjamin Baker, K.C.B.; Mr. Hurtzig; Sir John Wolfe Barry, Bart.; and Mr. Brereton. The author was resident engineer in charge of the works.

Personal Mention.

Mr. C. F. W. Felt, chief engineer of the Gulf, Colorado & Santa Fe at Galveston, Tex., has been appointed chief engineer of the Atchison, Topeka & Santa Fe, with office at Topeka, Kan.

Mr. F. B. Oren, supervisor of the Illinois Central at Fulton, Ky., has been appointed a roadmaster, with office at Mattoon, Ill., succeeding Mr. W. L. Love, resigned.

Mr. M. H. Hovey has been appointed as the expert in signaling and interlocking on the engineering staff which jointly serves the Railroad Commission of Wisconsin and the Wisconsin Tax Commission, reporting to Prof. W. D. Pence, who is engineer for the two state commissions. Mr. Hovey has served as signal engineer in the signal staff of the Illinois Central R. R. and other railroads and signal companies, and recently served as signal expert for the federal block signaling and train control board. Since then, however, he has served as superintendent of construction of the American Railway Signal Company, of Cleveland. He will resume his former service with the federal board in connection with his duties for the Wisconsin commission. Mr. Hovey's headquarters are at Madison, Wis.

Mr. Joseph E. Snell, superintendent of buildings and docks of the Delaware, Lackawanna & Western, has resigned and will engage in the contracting business with a New York concern.

Mr. Byron E. Woodcock has been appointed chief engineer of the East Broad Top Railroad & Coal Co., with office at Orbisonia, Pa., succeeding Mr. A. E. Bachert.

The position of superintendent of ways and structure, held by Mr. C. F. Blue with the Mobile & Ohio, has been abolished and Mr. Blue transferred to St. Louis. Beginning January 1, all roadmasters of the system will be under the direction of the superintendents of each division.

Mr. R. A. Klein has been appointed a supervisor of Division No. 1 of the West Jersey & Seashore, with office at Haddonfield, N. J., succeeding Mr. G. M. Ball, Jr., promoted. Mr. R. L. Kell has been appointed assistant supervisor of Division No. 3, with office at Millville, succeeding Mr. E. C. Silvius, transferred.

Mr. W. R. Hastings, general signal inspector of the Chicago, Rock Island & Pacific, has been appointed engineer of electric signals, with office at Chicago, succeeding Mr. E. W. Kolb, resigned; Mr. S. Misskelly, supervisor of signals at Rock Island, Ill., succeeds Mr. Hastings; Mr. G. W. Trout, acting signal supervisor at Trenton, Mo., succeeds Mr. Misskelly, and Mr. C. F. Duffy succeeds Mr. Trout, with office at Trenton.

Mr. E. W. Kolb, formerly with the Chicago, Rock Island & Pacific at Chicago, is now signal engineer of the Buffalo, Rochester & Pittsburg at Rochester, N. Y.

Mr. R. A. Rutledge, division engineer of the Gulf, Colorado & Santa Fe, at Cleburne, Tex., has been appointed general division engineer of the Gulf lines, with office at Galveston, Tex. This is a new office and Mr. Rutledge has special charge of maintenance and betterments, under the general supervision of Mr. F. Merritt, chief engineer, and all division engineers will report direct to him.

Mr. George D. Fairtrace has been appointed chief engineer of the Bartlett & Florence Railway, with office at Bartlett, Tex.

Mr. F. G. Jonah, terminal engineer of the New Orleans Terminal Company at New Orleans, La., has been appointed engineer of construction of the St. Louis & San Francisco, with office at St. Louis, Mo.

Mr. Arthur Caldwell has been appointed an assistant division engineer of the Baltimore & Ohio, with office at Washington, Ind., succeeding Mr. F. J. Parrish, resigned to engage in other business.

Mr. W. J. Bohan, electrical engineer of the Northern Pacific at St. Paul, Minn., has been appointed mechanical engineer, with office at St. Paul, succeeding Mr. J. E. O'Brien, resigned to go with another company.

Mr. W. L. Madill, supervisor of the Erie at Thompson, Pa., has been appointed supervisor of the Northern of New Jersey; the New Jersey & New York and the Piermont branch of the Erie, with office at Jersey City, N. J.

Mr. J. W. Snyder, assistant supervisor of signals on the Pittsburg division of the Pennsylvania Railroad at Pittsburg, Pa., has been appointed supervisor of signals of the Conemaugh division, with office at Pittsburg, succeeding Mr. B. F. Oler, transferred. Mr. Guy Toft succeeds Mr. Snyder, with office at Pittsburg. Mr. G. M. Ball, Jr., has been appointed supervisor of division No. 9 on the Middle divivsion, succeeding Mr. J. B. Hutchinson, Jr., promoted.

Mr. R. J. Arey, division engineer of the Atchison, Topeka & Santa Fe Coast Lines at San Bernardino, Cal.,, ,has been appointed engineer of the Grand division of the Coast Lines, with office at Los Angeles, Cal. This is a new office and Mr. Arey's territory is commensurate with that of the general superintendent's; he will relieve the chief engineer of direct charge of all division work. Mr. M. C. Bryan, assistant division engineer, succeeds Mr. Arey.

Mr. D. S. Watkins, division engineer of the Buffalo, Rochester & Pittsburg at Du Bois, Pa., has been appointed engineer of construction, in charge of construction of new lines, relocation of existinglines and such other duties as may be assigned, with office at Du Bois. Mr. W. F. Pond, assistant engineer of

George W. Daves.

bridges, at Rochester, N. Y., has been appointed office engineer, with office at Rochester. Mr. E. W. Hammond has been appointed division engineer of Divisions 1 and 2 and the Erie division, with office at Rochester, and Mr. G. C. Cleaver, assistant engineer of track, has been appointed division engineer of Divisions 3, 4 and 5, with office at Du Bois. The division engineers will have charge of track, bridges, buildings and water service. The offices of assistant engineer of track, and assistant engineer of bridges and buildings, have been abolished.

The Selling Side.

Mr. George W. Daves, now with Railroad Supply Company in the signal department, resigned November 1, 1909, from position of signal engineer of the Chicago & Alton Railroad. Mr. Daves entered railroad service as a messenger boy in 1898 with the Central Railroad of New Jersey; in 1899 he was in the civil engineering department and in 1900 the signal department of the same road. In November, 1906, he was appointed signal engineer of the Western Division of the Chicago & Alton Railroad and on September 1, 1908, he was signal engineer of the entire Chicago & Alton system.

Mr. Hugh M. Wilson, best known among our readers as the head of the Railway Age, now consolidated with the Railroad Gazette, who has for the last few months been connected with the Barney & Smith Car Company, Dayton, Ohio, as vice-president, has severed his connection with this firm to accept the position of first vice-president of the McGraw Publishing Co. to take effect March 1.

The W. K. Kenly Company will exhibit track devices at booths Nos. 78 and 79, Coliseum, Chicago, from March 14 to 19. The universal carrier base will be among the devices exhibited.

Burton W. Mudge & Company announce the appointment of Mr. Otto P. Hennig as sales manager. Mr. Hennig will have charge of sales, advertising and purchasing.

Mr. F. A. Hall, who for the past twelve years has been manager of the Chain Block and Hoist department of the Yale & Towne Manufacturing Company, whose general offices are at Nos. 9-13 Murray street, New York, and whose works are at Stamford, Conn., has resigned his position in order to accept election as vice-president and treasurer of the Cameron Engineering Company of Brooklyn, N. Y. Mr. Hall's successor will be Mr. R. T. Hodgkins, who for several years has been his chief assistant and who is thoroughly qualified by experience and ability successfully to perform the duties of the position. In his new connection Mr. Hall expects to make a specialty of trolleys and appliances for overhead handling of materials, and in connection therewith, to make use of the Yale & Towne blocks and hoists, with the sale of which he has so long and prominently been identified.

Mr. Otto P. Hennig has been appointed sales manager for Burton W. Mudge & Company, Railroad Supplies, Chicago.

The Buffalo, Rochester & Pittsburgh Railroad placed an order for a motor car of the 70 ft. design, similar to the one ordered by the Norfolk & Southern Railroad, with the McKeen Motor Car Company. The Rock Island Railroad has ordered a 70 ft. gasoline motor car for passenger and baggage service. The Rock Island has operated one of their 55 ft. cars for several months.

Mr. G. Brewer Griffin has recently been appointed manager and actively is directing the sales policy of the detail and supply sales department of the Westinghouse Electric & Mfg. Co., in which department transformers, meters, fans, heating appliances, switches, switchboards, railway line material, etc., are sold. Mr. Griffin has been assistant manager of this sales department for six years past, having previously been connected with the sale of detail apparatus in the Boston office, altogether having been employed some 7 years with this company. Previous to his connection with the Westinghouse Company, Mr. Griffin was with the Manhattan General Construction Company of New York as a special representative, finally opening an office for them in Boston.

Mr. Samuel A. Chase, who for the past few years has been with the Westinghouse Electric & Mfg. Company in their New York sales office as a special detail and supply salesman, has recently resigned to accept a position with the White Investing Company, of New York City, a financial investment company handling stock of many different organizations. Previous to Mr. Chase's employment with the Westinghouse Electric & Mfg. Company he was a salesman for the Western Electric Company, where he was highly successful. Mr. Chase will, after January 1st, be in charge of the Chicago office of the White Investing Company, having exclusive territorial rights in North and South Dakota, Minneapolis, Iowa, Illinois and northern Indiana.

Mr. S. L. Nicholson has recently been appointed general sales manager of the Westinghouse Electric & Mfg. Co., and has direct charge of the sales policies of the entire

Hugh M. Wilson.

company. Mr. Nicholson has been with the company for eleven years in many different capacities—as salesman, as district department manager, and as industrial and power sales manager for the past five years, from which last position he resigned to take the present post. Before coming to the Westinghouse company he was with the C. & C. Electric Company. He is perhaps best known to motor manufacturers as the organizer and president of the American Association of Motor Manufacturers, an organization which has done much in the two short years of its life to improve the art of manufacturing motors.

Mr. Charles Robbins, who has for many years been connected with the Westinghouse Electric & Manufacturing Company in the industrial and power sales department in connection with the sale of industrial motors, has recently been appointed manager of this department. Mr. Robbins has been with the company since 1899, in which time he has been in the manufacturing department, the New York district office sales department and for the past three years in the industrial and power sales department at East Pittsburg. His headquarters will continue to be at East Pittsburg.

Mr. J. E. Osmer has been appointed assistant superintendent of the Hicks Locomotive & Car Works, Chicago Heights, Ill., in charge of the locomotive works. Mr. Osmer has been master mechanic of the Northwestern Elevated R. R. of Chicago about six years, and previously was connected with the mechanical departments of the Iowa Central, C. & A., and C. & N. W.

John D. Conway, secretary of the Railway Supply Manufacturers' Association, 313 Sixth avenue, Pittsburg, Pa., has issued a circular announcing the principal features of the arrangements for the Master Car Builders' and Master Mechanics' conventions at Atlantic City, N. J., June 15-22 next. The exhibits and the offices of the association will be located on Young's Pier as before, with the exception of the track exhibits, which will be placed as they were in 1909, on the tracks of the Philadelphia & Reading Ry., about 200 yards from the convention pier. Contract has been let for the erection of exhibit structures. It provides for 69,000 sq. ft. of exhibit space, exclusive of aisles, and 40 cents per sq. ft. will cover the cost of erecting structures and providing the usual facilities. The color scheme will again be green and white. A telephone will be provided between every two exhibitors with free local service from Monday, June 13, to Thursday, June 23. Aquarium Court will have the column construction of previous years. The upper floor of Exhibition Hall will not be used, and the lower floor will have ceiling and walls calcimined white. Eight candle-power electric lamps will be placed 2 ft. apart along each of ten cornice lines and will be lighted throughout the day, so that each aisle will have two rows of these lights and each booth a row at the front and a row at the back. Annex court contains large spaces which may be built largely to suit occupants. The annex will have the column and panel construction substantially as in 1909, but very heavy exhibits cannot be placed on this end of the pier. Exhibits of medium heavy weight can be put in the addition to the hotel men's annex in the side spaces, as these are over concrete piles, but only light exhibits can go in the center spaces. Power for operating exhibits will be furnished as heretofore. An additional boiler and a larger motor-driven compressor will be installed, and it is expected that with these additions all reasonable demands can be met. On February 16, in Pittsburg, space will be assigned to all exhibitors who have made application prior to that date, and the procedure will be substantially the same as in 1909. The exhibitors, if any, whose requirements, in the judgment of the exhibit committee, make it imperative that they be specially taken care of, will be asigned space first. Lots will then be drawn to determine the order in which exhibitors may choose space. If a representative of the exhibitor is present, he may choose in his turn; if there is no representative present, the application will be used as a guide in assigning the best space possible. The number of advance applications already received indicates a very great demand for space. Mr. Conway gives the prices at which Joseph L. Shoemaker & Co., 926 Arch street, Philadelphia, will rent furniture for the eight days of the conventions, also rates for rugs. A complete list of hotels will be given in a later circular. Mr. Conway calls attention to the resolution of the executive committee, prohibiting the distribution of souvenirs at the conventions; and also to the rule prohibiting the distribution of advertising matter from booth to booth.

The International Steel Tie Co. held its first annual meeting of stockholders in the offices of the company in the Central Trust building, Altoona, Pa., recently. There was a large attendance of those carrying the stock and much enthusiasm was manifested over the outlook for the future of the corporation. The annual election was held and the following board of directors selected: V. A. Oswald, J. R. Boeckel, William P. Day of Altoona, and John P. O'Donnell, a retired iron manufacturer of Cleveland, and P. H. Lavin, secretary-treasurer of the Inter-State Steel Co. of the same city, and Harry Emmons of Delaware. The directors organized by the election of V. A. Oswald, president; George Marpham, secretary; S. M. Hoyer, treasurer, and W. P. Day, manager. The tie made by the company is winning the commendation of railroad managers everywhere and the outlook is very bright.

On Jan. 4th, 1910, Mr. F. F. Prentiss, on account of ill health, resigned from the presidency of the Cleveland Twist Drill Co., and Mr. J. D. Cox was elected to that office. Mr. Cox was the founder of this business and has always been the practical man of the concern. He has probably had as much experience and has been in as close touch with the manufacturing of twist drills as any other man living.

Geo. L. Kippenberger, for seven years purchasing agent of the St. Louis Car Co., St. Louis, Mo., has resigned that position and since January 1 has been connected with the Forsyth Bros. Co., Chicago. Mr. Kippenberger served as purchasing agent for the American Car Co., St. Louis, Mo., for eleven years before going to the St. Louis Car Co.

Mr. Fred A. Preston has been appointed general sales agent of the Railway Specialty & Supply Co. He will have charge of the sales department of this company, which manufacture the P. & M. rail anchor and other railway devices.

The Standard Railway & Timber Co. has been incorporated in Delaware, with a capital of $100,000. The incorporators are J. H. Scott, Tacoma, Wash.; E. H. Brehm, Seattle, Wash., and Joseph Irving, Everett, Wash.

The National Engineering & Construction Co. has been incorporated in Delaware, with a capital of $500,000. The incorporators are William S. McGuire, New York city; J. D. Fackenthal, Brooklyn, N. Y.; James W. Williams, Waston, Pa.

The Chesapeake & Western Ry. has one second hand 56-ton consolidation engine for sale.

The North Coast has ordered, from the Hicks Locomotive & Car Works, two 70-ton passenger locomotives. Delivery is specified for February.